KWAME NKRUMAH UNIVERSITY OF SCIENCE AND TECHNOLOGY KUMASI
SCHOOL OF GRADUATE STUDIES

ASSESSMENT OF THREE WHITE YAM (*Dioscorea rotundata*) VARIETIES FOR POSSIBLE DEVELOPMENT INTO FLOUR

SAMPSON BOATENG OFOSU

A THESIS SUBMITTED TO THE SCHOOL OF RESEARCH AND GRADUATE STUDIES,
KWAME NKRUMAH UNIVERSITY OF SCIENCE AND TECHNOLOGY, KUMASI. IN
PARTIAL FULFILLMENT OF THE REQUIREMENT FOR THE AWARD OF THE DEGREE
OF MASTER OF PHILOSOPHY (M.Phil.) IN POST HARVEST PHYSIOLOGY

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JUNE, 2012

DECLARATION

I hereby declare that, except for specific references which have been duly acknowledged, this project is the result of my own research and it has not been submitted either in part or whole for any other degree elsewhere.

Signature …………………………………… ………………………………….

SAMPSON BOATENG OFOSU Date

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(Head of Department)

ABSTRACT

A study was conducted to assess three white yam (*dioscorea rotundata*) varieties for possible development into flour in the Ashanti Region of Ghana from February to May, 2012. Field survey was conducted in five market centers in the Kumasi metropolis including Asafo, Bantama, Central (Bode), Krofrom (Moro) and Abinchi and one producing area in the Tanoso district of the Techiman municipality. Interviews, together with semi-structured questionnaires, were used in data collection from retailers and producers who were randomly selected from each location. Fifty retailers from the market centers and twenty farmers from the yam producing area. Laboratory work was also conducted at the Department of Horticulture of the Faculty of Agriculture, Faculty of Renewable Natural Resources, KNUST, Kumasi and Food Research Institute of the Council for Scientific and Industrial Research, Accra. Yam was collected from the Moro market in the Kumasi metropolis of the Ashanti Region, cut into chips and dried. They were them milled into flour and used for the laboratory work. The survey revealed that females (%) engaged in trading of the yam while the males engage in the farming. Education was, however, a problem for both yam farmers and traders. There were a lot of yam varieties in the country but majority of the respondent's interviewed preferred Pona because of its taste and size. Labreko was one second choice because it had a better taste compared to Pona while Dente was one third preferred choice.

Three yam cultivars were dried under three drying methods namely Solar, Sun and Oven. This study investigated the proximate, functional and pasting and colour properties of yam flour samples. The foam capacity, foam stability, Bulk density, swelling power, water and oil absorption index, moisture, protein and carbohydrate was investigated. Drying methods and cultivars were found to have significant effect ($P<0.05$) on the functional, colour, pasting and proximate properties of all the yam flour samples, There were significant differences ($p<0.05$) in the foam capacity (61.00 to 37.33)g/ml, foam stability (51.87 to 28.10)g/ml, Bulk density (0.85 to 0.81) g/ml, Swelling power (6.33 to 3.56)g/ml, Moisture (12.67 to 4.00)%, Protein (5.25 to 4.380%, Fat (1.32 to 0.50)%, Carbohydrate (84.80 to 74.19)% Peak viscosity (458.67 to 259.67) BU, Setback (119.00 to 10.33) BU, and Browning index (31.44 to 8.43)%. There were significant difference ($P<0.05$) in the Pasting properties as some are thicker than others and also some are lighter in colour than others. The study shows that the yam flour samples developed were significantly different ($p<0.05$) in terms of the proximate, functional, pasting and colour properties.

ACKNOWLEDGEMENT

I am greatly indebted to my supervisor Mr. Patrick Kumah and., who despite his busy schedule, supervised my work and whose constructive criticisms and guidance made this work a success.

I sincerely acknowledge the inestimable support of Dr. Francis Appiah, I say thank you for your care, support, help and suggestions in diverse ways. The good relationships we shared really kept me going.

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I appreciate all who contributed in one way or the other to this work but their names were not mentioned and above all I say thank you to the Almighty God for his goodness to me. All glory, honor and adoration to him for giving me this opportunity and all that it takes to finish it.

DEDICATION

Dedicated with love and the deepest appreciation to my sweet and lovely family. They gave me everything so I could have anything and even in the most difficult times they taught me to persevere and move forward and never look back no matter what.

LIST OF ABBREVIATIONS

CRI	Crop Research Institute
CSIR	Council for Scientific and Industrial Research
FAO	Food and Agriculture Organization
FRI	Food Research Institute
GDP	Gross Domestic Product
GEPC	Ghana Export Promotion Council
ICRA	International Centre for Development-Oriented Research in Agriculture
IECT	Impact Evaluation Consulting Team
IITA	International Institute of Tropical Agriculture
KMA	Kumasi Metropolitan Assembly
KNUST	Kwame Nkrumah University of Science and Technology
MiDA	Millennium Development Authority
MoFa	Ministry of Food and Agriculture
NFE	Nitrogen Free Extract
NRI	Natural Resources Institute

TABLE OF CONTENTS

TITLE PAGE…… ii

DECLARATION…… iii

ABSTRACT…… iv

ACKNOWLEDGEMENT…… vi

DEDICATION…… vii

LIST OF ABBREVIATIONS…… viii

TABLE OF CONTENTS…… ix

LIST OF TABLES…… xvii

LIST OF FIGURES…… xix

LIST OF PLATES…… xx

LIST OF APPENDICE…… xxi

1.0 INTRODUCTION…… 1

2.0 LITERATURE REVIEW…… 4

2.1 YAM…… 4

2.1.1 Origin and Distribution…… 4

2.1.2 Description of the Yam Plant…… 6

2.1.2.1Stem…… 6

2.1.2.2Leaves…… 6

2.1.2.3 Tubers……7

2.2 PRODUCTION…… 7

2.3 EXPORTS…… 10

2.4 ECOLOGY…… 12

2.5 HARVEST........ 13

2.6 YAM STORAGE........ 13

2.7 POST HARVEST LOSSES OF YAM........ 14

2.8 CHEMICAL AND NUTRITIONAL COMPOSITION OF YAMS........ 14

2.9 YAM VARIETIES 15

2.9.1 White yam (*Dioscorea rotundata*)........ 16

2.9.2 Yellow yam (*Dioscorea cayensis*)........ 17

2.9.3 Water yam (*Dioscorea alata L.*)........ 18

2.9.4 Bitter yam (*Dioscorea dumentorum*)........ 18

2.9.5 Chinese yam (*Dioscorea opposita*) 18

2.9.6: Air potato (*Dioscorea bulbifera*)........ 19

2.9.7 Cush-Cush yam (*Dioscorea trifida*)........ 20

2.10 ANTI-NUTRITIONAL FACTORS OF YAM 20

2.11 UTILIZATION AND PROCESSING TECHNIQUES 21

2.12 DRYING 21

2.12.1 Sun Drying........ 22

2.12.2 Solar Drying 23

2.12.3 Oven Drying 23

2.13 YAM CHIPS 24

2.14 IMPORTANCE OF YAM CHIPS 26

2.15 PROBLEMS ENCOUNTERED DURING YAM CHIPS PRODUCTION 26

2.16 YAM FLOUR 26

3.0 MATERIALS AND METHOD 28

3.1 FIELD SURVEY... 28

3.1.1 Questionnaire Construction 28

3.1.2 Sampling Area... 28

3.1.3 Questionnaire Administration.. 29

3.1.4 Statistical Analysis 29

3.2 LABORATORY EXPERIMENTS 29

3.2.1 Location of Experiment 29

3.3 METHOD.. 30

3.3.1 Preparation of yam chips and flour.. 30

3.4 PROXIMATE COMPOSITION STUDIED.. 32

3.4.1 Proximate Analysis.. 32

3.4.1.1 Moisture.. 32

3.4.1.2 Ash Determination.. 32

3.4.1.3 Ether Extract (Fat) Determination.. 33

3.4.1.4 Crude Fiber Determination.. 34

3.4.1.5 Crude Protein Determination 34

3.4.7 Calculation of Nitrogen-Free Extract 35

3.5 FUNCTIONAL PROPERTIES STUDIED... 35

3.5.1 Functional Properties... 35

3.5.2 Bulk density.. 35

3.5.3 Water and oil absorption capacities.. 36

3.5.4 Foam capacity and stability 36

3.5.5 Swelling power 36

3.5.6 Gelation Capacity 37

3.5 7 Pasting Characteristics.. 37

3.5.8 Colour Determination... 38

3.6 EXPERIMENTAL DESIGN.. 39

3.7 STATITICAL ANALYSIS 39

4.0 RESULTS 40

4.1 INTRODUCTION.. 40

4.2 FIELD SURVEY.. 40

4.2.1 Background Information on Retailers and Producers.. 40

4.2.2 Production Practices Carried Out. 45

4.2.3 Knowledge on Flour Production.. 47

4.2.4 Post Harvest Handling……………………………………………………………. 49

4.3 Temperature and Humidity Records 49

4.4 FUNCTIONAL PROPERTIES 51

4.4.1 Foaming capacity.. 51

4.4.2 Foaming Stability 52

4.4.3 Water Absorption Capacity 57

4.4.4 Bulk Density……………………………………………………………… 57

4.4.5 Solubility 58

4.4.6 Oil Absorption.. 59

4.4.7 Swelling Power 60

4.4.8 Least Gelation Concentration 61

4.5 PROXIMATE ANALYSIS 62

4.5.1 Moisture... 62

4.5.2 Ash... 63

4.5.3 Protein.. 64

4.5.4 Fat 65

4.5.5 Fiber.. 66

4.5.6 Carbohydrate / NFE... 67

4.6 PASTING PROPERTIES 71

4.6.1 Peak Viscosity.. 71

4.6.2 Pasting Stability.. 72

4.6.3 Setback.. 73

4.6.4 Breakdown………………………………………,……………………… 73

4.7 COLOUR PROPERTIES.. 78

4.7.1 Browning Index.. 78

5.0 DISCUSSION.. 81

5.1 SURVEY…………………………………………………………………… 81

5.1.1 Background Information on Retailers and Producers.. 81

5.1.2 Production Practices Carried Out.. 82

5.1.3 Knowledge on Flour Production.. 82

5.1.4 Post Harvest Handling…………………………………………………… 83

5.2 LABORATORY STUDIES.. 83

5.2.1 FUNCTIONAL PROPERTIES.. 83

5.2.1.1 Bulk Density…………………………………………………… 83

5.2.1.2 Water Absorption…………………………………………………… 83

5.2.1.3: Oil Absorption…………………………………………………… 85

5.2.1.4: Swelling power…………………………………………………… 86

5.2.1.5: Solubility…………………………………………………… 87

5.2.1.6: Foam Capacity and Stability……………………………………… 88

5.2.1.7: Least Gelation Concentration……………………………………… 89

5.2.2 PROXIMATE ANALYSIS………………………………………………… 90

5.2.2.1 Moisture Content…………………………………………………… 90

5.2.2.2 Ash……………………………………………………………………… 91

5.2.2.3 Protein………………………………………………………………… 91

5.2.2.4: Crude Fat…………………………………………………………… 92

5.2.2.5 Crude Fiber…………………………………………………………… 93

5.2.2.6: Carbohydrate Content……………………………………………… 94

5.2.3 PASTING PROPERTIES………………………………………………… 95

5.2.3.1 Peak Viscosity……………………………………………………… 96

5.2.3.2 Pasting Temperature………………………………………………… 97

5.2.3.3 Peak Times…………………………………………………………… 97

5.2.3.4 Setback……………………………………………………………… 98

5.2.3.5 Breakdown…………………………………………………………… 99

5.2.4 COLOUR PROPERTIES………………………………………………… 99

5.2.4.1 Browning Index……………………………………………………… 99

6.0 CONCLUSIONS AND RECOMMENDATIONS…………………………… 101

6.1 CONCLUSIONS……………………………………………………………… 101

6.2 RECOMMENDATIONS 102

REFERENCES.. 103

APPENDICES 118

LIST OF TABLES

Table 2.1: Ghana Total Yam Exports …………………………………........................... 10

Table 2.2: Nutritional Composition of some Yam species …………………………..… 15

Table 4.1: Age distribution of retailers 42

Table 4.2: Age distribution of producers.. 43

Table 4.3: Effect of Drying Methods of Yam Flours on the Functional Properties 54

Table 4.4: Effect of Varieties of Yam Flours on the Functional Properties 55

Table 4.5: Effect of Yam Flours on the Functional Properties..................................... 56

Table 4.6: Effect of Drying Method and cultivar on the least gelation concentration of yam under sun dried …………………………………………….. 61

Table 4.7: Effect of Drying Method and cultivar on the least gelation concentration of yam under solar dried …………………………………………... 62

Table 4.8: Effect of Drying Method and cultivar on the least gelation concentration of yam under solar dried ………………………………………….. 62

Table 4.9: Effect of Proximate analysis on the drying methods.................................... 68

Table 4.10: Effect of Proximate analysis on the Yam Varieties...................................... 69

Table 4.11: Effect of Proximate analysis on the Yam Flour Samples.............................. 70

Table 4.12: Effect of Pasting Properties on the drying methods....................................... 75

Table 4.13: Effect of Pasting Properties on the Yam Varieties... 76

Table 4.14: Effect of Pasting Properties on the Yam Flour Samples................................ 77

Table 4.15: Effect of Colour Properties on the drying methods 79

Table 4.16: Effect of Colour Properties on the varieties.. 79

Table 4.17: Effect of Colour Properties on the yam flour samples 80

LIST OF FIGURES

Figure 2.1: Export of Ghanaian Yam.. 11

Figure 2.2: Ghana Yam Exports by Importing Country, 2008 11

Figure 3.1: Flow Chart showing Production of Yam.. 31

Figure 4.1: Gender of retailer respondents.. 41
Figure 4.2: Gender of producer respondents.. 41
Figure 4.3: Educational background of retailers... 44
Figure 4.4: Educational background of producers... 44
Figure 4.5: Cultivars of yam sold by the retailers... 46
Figure 4.6: Cultivars of yam sold produced in the tanoso district 46
Figure 4.7: Cultivars of yam used for fufu by the retailers... 48
Figure 4.8: Cultivars of yam used for fufu by the producers... 48
Figure 4.9: Cumulative percentage weight loss of yam chips with time 50
Figure 4.10:Temperature 0f drying environment over time... 50
Figure 4.11:Relative humidity of dying environment over time.. 51

LIST OF PLATES

Plate 2.1: Yam Production in Ghana, 2003……………………………………… ….. 9

Plate 3.1: labreko cultivar .... ….. 16

Plate 3.2: dente cultivar.. ….. 16

Plate 3.3: pona cultivar.. …... 17

Plate 3.4: fresh yam chips .... …………… 25

Plate 3.5: yam flour samples .... ……. 27

LIST OF APPENDICE

Appendix a: frequency tables for the field survey 118

Appendix b: analysis of variance (anova) tables 121

Appendix c: sample questionnaire administered to yam retailers and producers………………….137

1.0 INTRODUCTION

Yam is a polyploidy and vegetatively propagated tuber forming and liana type plant that is cultivated in the yam belt of West and Central Africa and generally classified in the order of *Dioscoreales* and of the family *Dioscoreaceae*. Although generally attributed to monocotyledons, it shows features of some dicotyledons plants (Ayensu, 1992).

Yams are climbing monocotyledonous vines with large strong underground tubers and more than 600 species of Dioscorea exist however, only six are mostly grown as staple food in West Africa. Few species are cultivated, the most widespread being *Dioscorea rotundata* Poir, *Dioscorea alata* L., *Dioscorea dementorum* (knuth) Pax, *Dioscorea Cayenensis* Lam, *Dioscorea esculenta* (Lour) Burk and *Dioscorea bulbifera* L. (Terauchi *et al*., 1993). Of these species of yam, *Dioscorea esculenta* (Lour) Burk and *Dioscorea bulbifera* L. are not commonly found in the markets hence only a low percentage of the population uses them for food (Terauchi *et al*., 1993).Yams are an integral part of food systems particularly in West Africa where they are estimated to provide more than 200 dietary calories each day for over 60 million people (Otegbayo *et al*., 2001).

Yam is a good source of energy; 100 g provides 118 calories. It is mainly composed of complex carbohydrates and soluble dietary fiber (Mateljan, 2011). Tubers are used various traditional medicines in China, Korea and Japan. The mucilaginous tuber milk contains allantoin, a cell-proliferant that speeds the healing process when applied externally to ulcers, boils and abscesses. Its decoction is also used to stimulate appetite and to relieve bronchial irritation and cough. (Anon, 2009).

Ghana is second after Nigeria in terms of volume of production (FAO, 2005) but Ghana is the world's largest exporter of yams (MiDA, 2008). Ghana exports approximately 21,000 metric tons of yams annually, a number that had been increasing over the last decade (MiDA, 2008). The compound annual growth rate of yam exports between 2000 and 2008 was 6.6 % (MiDA, 2008).

Many species of yam are grown and distinguished from each other by the colour of the flesh of the tubers, the morphology of leaves and stems of flowers (Okigbo and Nwakammah, 2005). It's role in food security is justified by its potential energy, its insensitivity to climatic conditions (Bricas, 1998) and the adoption as a staple in Africa well before the introduction of new crops into the new world such as corn, cassava. These seasonal foods deteriorate easily during storage, thus, it's of great importance to prolong the storage of yams for supplying in the off-season and without losing nutritional functionality (Afoakwa and Sefa-Dedeh, 2001). More often than not, farmers encounter problems with storage losses emanating from physiological changes, which include sprouting, transpiration, respiration (which depend on the storage environment- mainly temperature and relative humidity), rots due to mould and bacteriosis, and attack by insects, nematodes and mammals (Afoakwa and Sefa-Dedeh, 2001).

Fresh yams are difficult to store and are subject to postharvest losses during storage (Otunsanya and Jeger, 1996; Afoakwa and Sefa-Dedeh, 2001). These losses serve as an impetus for processing this staple food into a product of longer shelf life. Yam flour can be easily stored for a long period (12 - 18 months) if the flour is free from moisture; hence yam is commonly processed into flour by drying yam slices and milling (Afoakwa and Sefa-Dedeh, 2001).

In recent years, much attention has been drawn to the quality of dehydrated food products. Drying methods and the physicochemical changes that occur in tissues during drying affect the quality of the dehydrated products (Krokida *et al.*, 1998). Since flours can be easily stored for long period of time and conveniently used in manufacturing formulated foods or capsules for consumption, dried yam flour is worth developing (Krokida *et al.*, 1998). To reduce such postharvest losses fresh yams are dehydrated through a drying process (Attai *et al.*, 1998; Hounhouigan, 1998; Babajide *et al.*, 2007) and to overcome the problems of loss and seasonal supply of yams, a transformation into chips was initiated by farmers and later processed into less perishable products such as flour (Akissoe *et al.*, 2003).

This work was done with the primary aim assessing various yam varieties on the market which can be processed into flour for long term storage and the specific objectives were to determine;

- the three most popular yam varieties and the most appropriate variety for flour development,
- an appropriate drying method for yam flour production and the effect of different drying methods on the proximate composition and functional properties of developing flours, and
- the pasting characteristics of the flours developed to find which could be used for various food preparations.

2.0 LITERATURE REVIEW

2.1 YAM

2.1.1 Origin and Distribution

The genus *Dioscorea*, a variety of yam has wider diversity of origin with different species adapted to different ecosystems. *D.trifida* is indigenous to tropical America: *D.rotundata*, *D.cayenensis*, *D.bulbifera* and *D.dumetorum* are native to West Africa; *D.alata*, *D.esculenta* and *D.opposite* are indigenous to South Asia. *D.opposite* and *D.japonica* have their center of origin in China (FAO, 1990).

The family Dioscoreaceae is believed to be among the earliest angiosperms and probably originated in Southeast Asia. The various *Dioscore*a species apparently followed a divergent evolutionary course in three continents separated by the formation of the Atlantic Ocean and desiccation of the Middle East. Accordingly, the major food species originated from three isolated centers: Africa, Southeast Asia and South America. These centers also considered areas for independent yam domestication, and represent considerable diversity (Oli, 2006).

Yams are starchy staples in the form of large tubers produced by annual and perennial vines grown in Africa, the Americas, the Caribbean, South Pacific and Asia. There are hundreds of wild and domesticated *Dioscorea species*. White Guinea yam, *D.rotundata*, is the most important species especially in the dominant yam production zone in West and Central Africa. It is indigenous to West Africa, as is the Yellow yam, *D.cayenensis*; Water yam, *D.alata* which is the second most cultivated species, originated from Asia and is the most widely distributed species in the world (IITA, 2009).

Yams are the only root crops in which the Asian and African species developed independently of each other. Exchange of species was due to the influence of Portuguese explorers. They learned of the value of *D.alata* from the Indian and Malayan seafarers who used it on their ships on long voyages because it stored well and had antiscorbutic properties. The Portuguese soon adopted it and introduced it into Elmina and Sao Tome in West Africa. Subsequently, through the Atlantic slave trade, the Portuguese carried the African species *D.rotundata* and *D.cayenensis* and the Asian species *D.alata* to the Caribbean where they became important staple foods. *D.cayenensis* is of African origin, where it is known as "water yam", indicating it was brought across the water or sea. D.*rotundata* is the most important African yam, especially in the forest zone, and is probably a hybrid of the other African yam, *D.cayenensis*, which is a savannah species. In West Africa it is grown in the roots and tubers belt, which extends 15^0N and 15^0S of the equator (FAO,

1990).

Little is known about the origin of new world yams. They were of secondary importance in the pre-Colombian era. *D.trifida*, an Amerindian domesticate, appears to have originated on the borders of Brazil and Guyana, followed by dispersion through the Caribbean. Yams were taken to the Americas through pre-colonial Portuguese and Spanish expansion that began around 500 years ago. Historical records of *D.alata* in West Africa and of African yams in the Americas date back to the sixteenth century (FAO, 1990).

2.1.2 Description of the Yam Plant

In West Africa several yams species are cultivated of which the native *Dioscorea rotundata* is the most important. Yam tubers can grow up to 1.5 m (4.9 ft.) in length and weigh up to 70 kg (154 lb.) and 3 to 6 inches high. The vegetable has a rough skin which is difficult to peel, but which softens after heating. The skins vary in color from dark brown to light pink. The majority of the vegetable is composed of a much softer substance known as the "meat". This substance ranges in color from white or yellow to purple or pink in mature yams (Tweneboah, 2000).

2.1.2.1 STEM

The stem is cylindrical sometimes spiny at the base. Have smooth vines and climbing habit is anticlockwise (Tweneboah, 2000). Only known in cultivation, it also differs from the other cultivated species by having round, and glabrous stems (Perla and Bakary, 1990).

2.1.2.2 LEAVES

The leaves of *D.rotundata* are chordate and opposite. They are pale green in colour, long and narrow pointed (Tweneboah, 2000).

2.1.2.3 TUBERS

The shape of the tuber is very variable but most cultivars in West Africa are often long and cylindrical or lobed, although some produce short, thick rounded tubers. White yam tubers remain dormant for 2-3 months after harvest and therefore store well compared with the tubers of species with short or no dormancy. The tubers of ‘pona’ are larger than that of ‘Labreko’, and it almost has a depression of the “head” (Tweneboah, 2000).

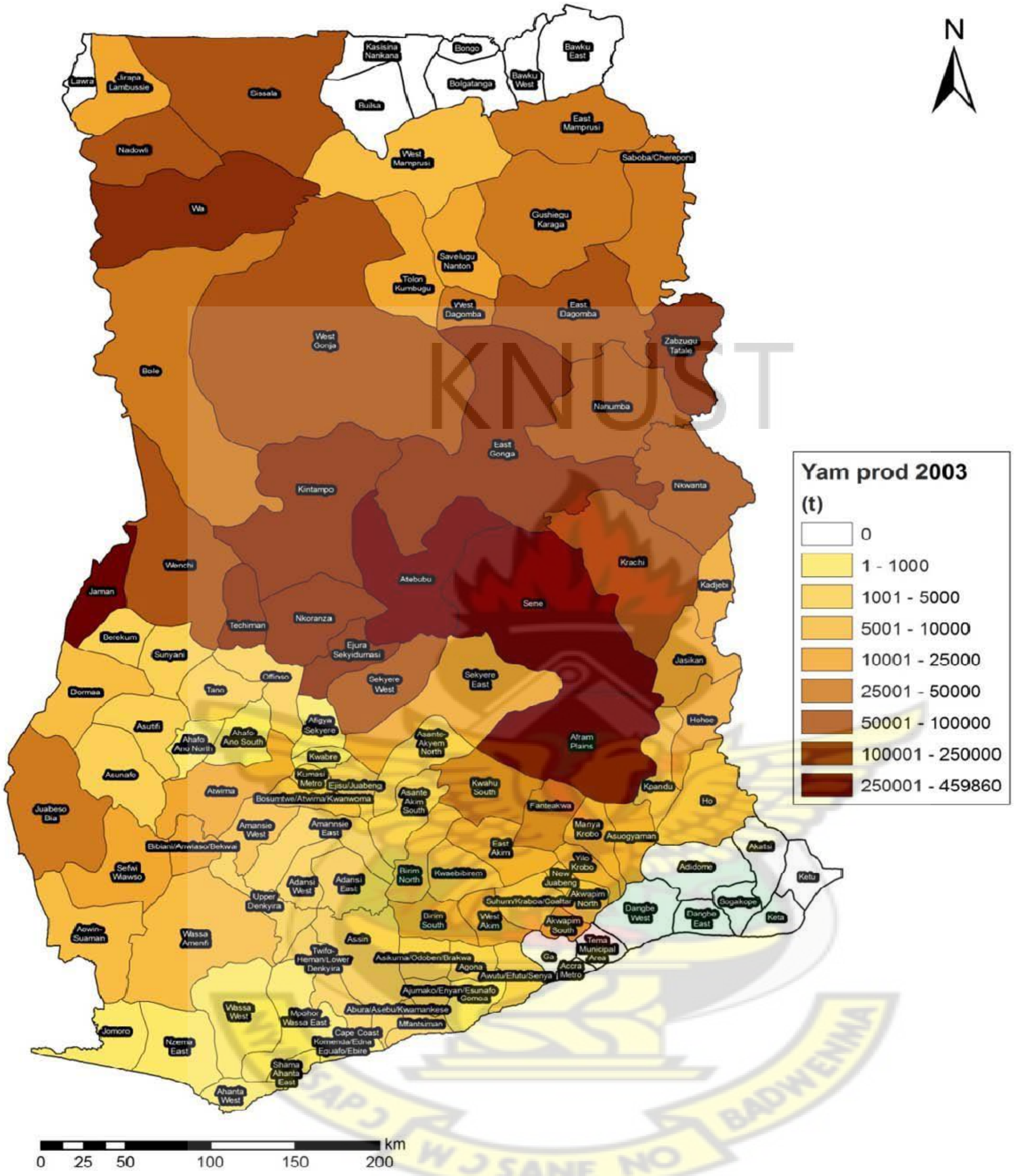
2.2 PRODUCTION

Yam is an important crop in Ghana and is produced throughout most of the country, as is illustrated by the production map available in Annex I. In fact, Ghana is the third largest producer of yams in the world, behind Nigeria and Cote d’Ivoire. Ghana produced approximately 4 million metric tons of yam in 2005, compared to approximately 34 million metric tons produced in Nigeria and 5 million metric tons produced in Cote d’Ivoire. Following Ghana is Benin, with a production of about 2.1 million metric tons, and Colombia, Brazil, and Japan with smaller quantities of production at around 200,000 metric tons in 2005. (MiDA, 2008).

Yam is an extremely vital crop, not only to the domestic market but also to the export market. Domestically, it is not only a main source of income, but it is a staple crop vital to food security. Internationally, customers desire the sweeter taste of the well-known “Ghana yam”. Nevertheless, the lack of planting materials is a major constraint in yam production. Seeds are needed to create a more efficient and affordable growing process that can yield better quality yams. (MiDA, 2008).

In Ghana, a variety of yams are grown, but the white yams, especially the Pona (sometimes Puna) variety, are preferred by both the domestic and export market. Pona is so desirable that it is often difficult to find enough Pona tubers, especially during June and August, when it is off season. Other popular varieties include Dente, Asana and Serwaa. The growing cycle for yams ranges from six to eight months depending on the variety, with planting occurring between February and April, and harvesting occurring in October. (MiDA, 2008).

Yams are grown by small scale farmers using traditional methods for seed generation. This involves "milking" or harvesting the yam tubers (also known as ware yams) early and using the seed yams that result from this process for planting. However, this results in a poorer quality, and sometimes diseased tubers. Other methods for growing yams include using the yam head or other parts of the yam that can sprout to produce seeds. The challenge with these techniques is that they do not result in a large number of yams, and often times, the quality of seeds produced can be poor. (MiDA, 2008).



Source: Crops Research Institute, 2003

Plate 2.1: YAM PRODUCTION IN GHANA, 2003

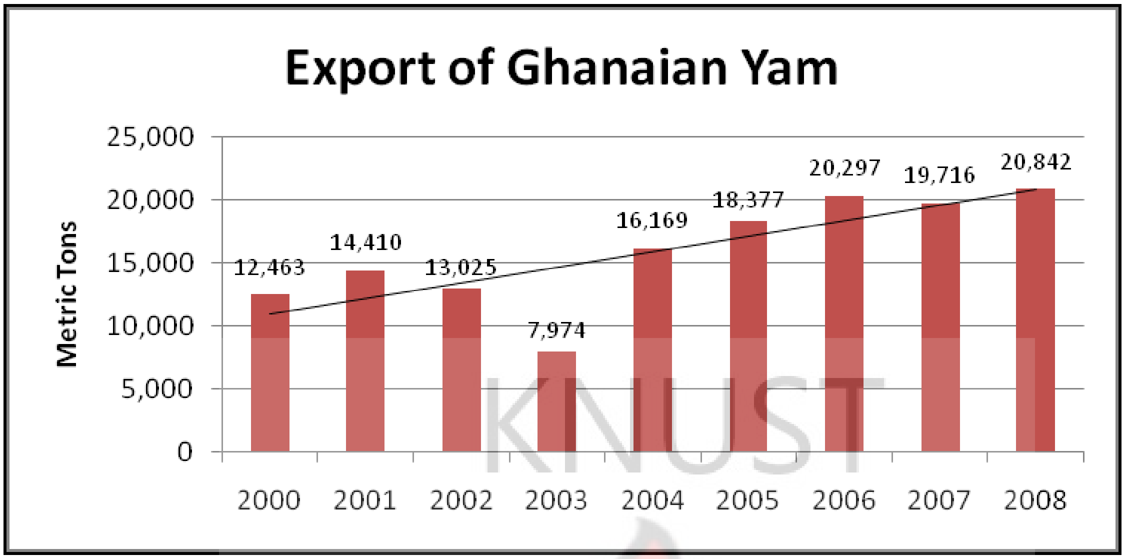
2.3 EXPORTS

Ghana exports more yam annually than do Nigeria or Cote d'Ivoire, the world's two largest yam producers. Ghana is currently exporting approximately 21,000 metric tons of yams annually, a number that has been increasing over the last decade. The compound annual growth rate of yam exports between 2000 and 2008 is 6.6%.

Table 2.1: GHANA TOTAL YAM EXPORTS

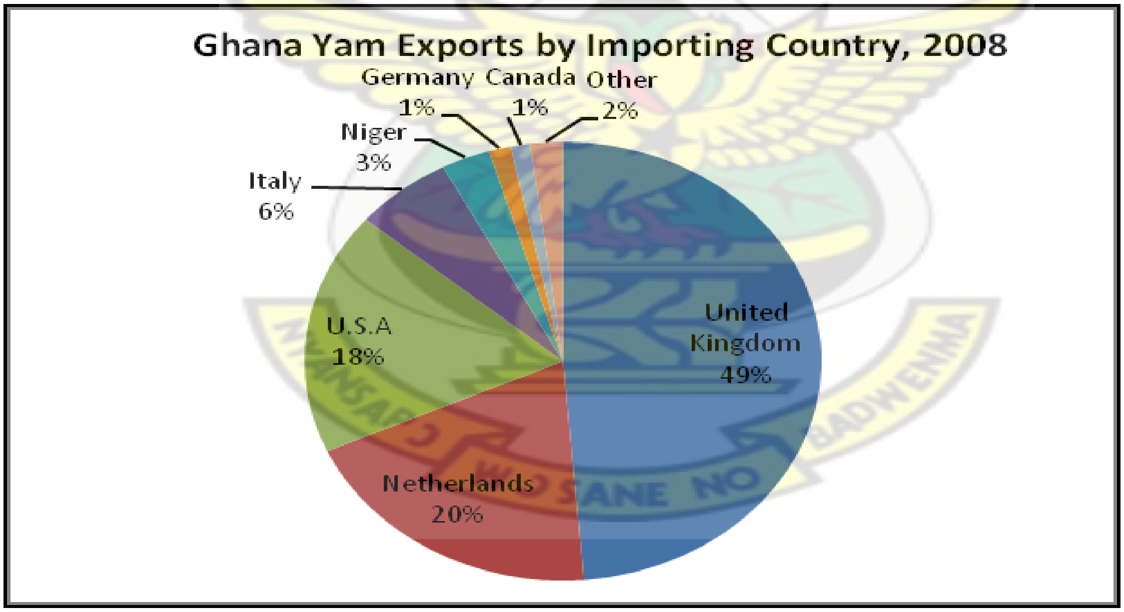
Year	Metric Tons	Value USD	Value GHC
2000	12,463	7,171,764	10,040,470
2001	14,410	7,785,770	10,900,078
2002	13,025	8,247,906	11,547,068
2003	7,974	4,442,386	6,219,340
2004	16,169	8,339,850	11,675,790
2005	18,377	10,951,354	15,331,896
2006	20,297	14,156,905	19,819,667

Source: Ghana Export Promotion Council, 2009



Source: Ghana Export Promotion Council, 2009

Figure 2.1: Export of Ghanaian Yam



Source: Ghana Export Promotion Council, 2009

Figure 2.2: Ghana Yam Exports by Importing Country, 2008

2.4 ECOLOGY

The edible yams are tropical crops which cannot tolerate frost. They do not grow well below 20^{0}C and within the range 25-30^{0}C, growth increases with T^{0}C. *D.opposite* can be grown under colder conditions than the other spp. Tuber development is an evolutionary adaptation to a dry season, when leafy shoots die away and tubers become dormant. They require at least 1000mm of rainfall per annum, but higher rainfalls are preferred. Savannah spp., such as *D.rotundata* and *D.alata* usually require a growing period of 7-8 months to complete their life cycle. At low rainfalls below 1000mm small crops may be produced, but seed yams are not obtained. The critical period is during 14-20 weeks of growth when the food reserves of the sett are almost exhausted and the shoots are making rapid growth before new tubers have been formed. Later they can stand periods of drought but yields are reduced (Purseglove, 1992).

The effect of photoperiod has not been fully investigated, but long days appear to favour development of the vine and short days to favour tuber growth. Yams require reasonable soil fertility and they are usually the first crops taken in the cropping cycle during shifting cultivation. They grow best in loose, deep, free-draining soil, and they cannot tolerate water logging (Purseglove, 1992).

To sum up the ideal conditions for yams are: a temperature of 30^{0}C, a dry season of not more than 2-4 months; a rainfall of at least 1500mm evenly distributed throughout the remainder of the year and deep, friable, fertile soils. In West Africa the Northern limit of the yam zone is about 10^{0}N beyond which the dry season is too long and the Southern limit is set by the coastal areas and the low lying swampy lagoons, as is found in the Niger delta (Purseglove, 1992).

2.5 HARVEST

There are many varieties of yams and farmers plant a mixture of early- and late-maturing ones in order both to obtain seed from those which can be double-harvested, and to be able to stagger the harvest in order to extend the consumption period and/or even-out the flow of income from crop sales. Langyintuo, 1993 reports that farmers cultivate an average of five varieties, of which three are early-maturing, while about 30 varieties are commonly grown throughout the country. Popular varieties include those which produce large tubers and those with a strong market demand, whilst other favoured characteristics apart from the time they take to mature, include overall yield, taste, suitability for making *fufu* and 'storability'. The main species in Ghana is *Dioscorea rotundata* which accounts for approximately 80 per cent of species cultivated. *Dioscorea alata* makes up most of the balance (Peters *et al*, 1997).

The tubers are delicate and are easily bruised during harvest (aggravated by the fact that the soil tends to be hard and dry at harvest time), subsequent handling and transportation to market. Bruising results in a decline in quality (Bancroft *et al*, 1998) and predisposes tubers to infection by storage fungi.

2.6 YAM STORAGE

Yam tubers are ripe for harvesting when the foliage dies. Harvesting takes place afterwards or tuber can simply be left in ridges. The duration of the time of storage depends on the particular variety of yam and corm extends over one-four months (Coursey, 1983). In Nigeria, yam is stored in clamp silos. The technique of storage originated from experience gained in northern Europe. The storage for varieties of yam varies in comparison to traditional yam barn. The clamp silos was met with little acceptance for the storage of yams among the local population for socio- economic reasons (Coursey, 1976).

2.7 POSTHARVEST LOSSES OF YAM

Deterioration following the harvesting of fresh roots and tubers and the consequent losses are caused by:

- Mechanical damage
- Physiological changes within the plant
- Infections caused by decay organisms and pest infestation (Ketiku *et al.*, 1973)

2.8 CHEMICAL AND NUTRITIONAL COMPOSITION OF YAMS

Root and tuber crops are second only in importance to cereals as a global source of carbohydrates. They also provide some minerals and essential vitamins, although a proportion of the minerals and vitamins may be lost during processing. The lesser known yams have been reported by Eka (1998) to be rich in crude protein than other varieties and are relatively high in Ash, which are concentrated in the peels. The starch contents are also highly digestible and they are good sources of vitamin B complex and vitamin C. In some parts of Africa the diet is supplemented with the tender leaves of sweet potato, cassava and cocoyam which are rich sources of protein, minerals and vitamins (Hahn, 1984). The yam tuber contains 15.25% starch and 2.5% on fresh weight and 4 – 12.5g on dry weight basis. The protein is low in histidine, cystine, methionin and valine. They are fairly good sources of vitamin C. They are usually high in Fe but low in Ca, Na and Zn. Protein and moisture level increases from head to tail end of the tuber. The peel contains more fibre, ash, protein, calcium, and iron, than the edible parts of tubers (Ketiku *et al*., 1973). Yams are superior to cassava as a source of protein and displacement of yams by cassava increases the incidence of kwashiorkor. (Ketiku *et al*., 1973).

2.9 YAM VARIETIES

The genus Dioscorea contains a wide range of yam species used as food. There are many varieties of yam species widespread throughout the humid tropics; the most economically important species which are grown are White yam (*Dioscorea rotundata*), Yellow yam (*Dioscorea cayensis*), Water yam (*Dioscorea alata*), Chinese yam (*Dioscorea esculenta*) Aerial yam (*Dioscorea bulbifera*) and Trifolate yam (*Dioscorea dumentorum*), (Ike and Inoni, 2006).

Table 2.2: Nutritional Composition of some Yam species

Species	Moisture	CHO	Fat	Protein	Fiber	Ash
D. alata	73.83	83.33	0.58	7.26	2.29	5.16
D. cayensis	83.40	87.82	0.39	6.15	2.44	3.20
D. rotunda	73.83	87.92	0.46	5.87	2.38	4.20
D. esculenta	81.38	83.08	0.54	8.73	3.45	4.20

Source: F.A.O., 2001

2.9.1 White yam (*Dioscorea rotundata*)

This originated in Africa and is the most widely grown and preferred yam species. The tuber is roughly cylindrical in shape; the skin is smooth and brown and has a white firm flesh. A large number of white yams exist with difference in the production and Post-harvest characteristics. (Kay, 1987).

Some varieties of *Dioscorea rotundata* which will be used for this study are shown in the plates below:

Plate 2.2: Labreko Cultivar

Plate 2.3: Dente Cultivar

Plate 2.4: Pona Cultivar

2.9.2 Yellow yam (*Dioscorea cayensis*)

Derives it common name from it yellow flesh, which is caused by the presence of carotenoids. It is also native to West Africa. The yellow yam has a longer period of vegetation and a shorter dormancy than white yam. In the past Yellow yam and White yam were considered as two separate species but most taxonomists now regard them as the same species, there are over 200 cultivated varieties between them. The Kokoro variety isimportant in making dried yam chips. They are large plants; the vines can be as long as 10 to 12 meters (35 to 40 feet). The tubers most often weigh about 2.5 to 5 kg (6 to 12 lbs.) each but can weigh as much as 25 kg (60 lbs.). After 7 to 12 months growth the tubers are harvested. In Africa most are pounded into a paste to make the traditional dish of "pounded yam" (Kay, 1987).

2.9.3 Water yam (*Dioscorea alata L.*)

Originated from South East Asia, it is the species most widely spread throughout the world and in Africa its second only to white yam in popularity called "water yam", "winged yam" and "purple yam". Water yam was first cultivated in Southeast Asia. It has the largest distribution world-wide of any cultivated yam, being grown in Asia, the Pacific islands, Africa, and the West Indies (Mignouna, 2003). In the United States it has become an invasive species in some Southern states. The tubers shape is generally cylindrical but can be extremely variable. Tuber flesh is white and watery in texture. (Kay, 1987).

2.9.4 Bitter yam (*Dioscorea dumentorum*)

Bitter yam also called trifoliate yam because of its leaves. Originated from Africa where wild cultures also exist. One-marked characteristics of the bitter yam is the bitter flavour of its tuber. Another undesired characteristics is that the flesh hardness if not cooked soon after harvest. Some wild cultures of this species are also poisonous. (Kay, 1987).

2.9.5 Chinese yam (*Dioscorea opposita*)

The Chinese yam plant is smaller than the African, with the vines about 3 meters (10 feet) long. It is tolerant to frost and can be grown in much cooler conditions than other yams. It is now grown in China, Korea, and Japan. It was introduced to Europe in the 1800s when the potato crop was falling victim to diseases, and is still grown in France for the Asian food market. The tubers are harvested after about 6 months of growth. Some are eaten right after harvesting and some are used as ingredients for other dishes, including noodles, and for traditional medicines (Kay, 1987).

2.9.6: Air potato (*Dioscorea bulbifera*)

This is found in Africa and Asia, with slight differences between those found in each place. It is a large vine, 6 meters (20 ft.) or more in length. It produces tubers; however the bulbils which grow at the base of its leaves are the more important food product. They are about the size of potatoes (hence the name "air potato"), weighing from 0.5 to 2 kg (1 to 5 lbs.). Some varieties can be eaten raw while some require soaking or boiling for detoxification before eating. It is not grown much commercially since the flavor of other yams is preferred by most people (Schultz, 1993).

However it is popular in home vegetable gardens because it produces a crop after only four months of growth and continues producing for the life of the vine, as long as two years. Also the bulbils are easy to harvest and cook (Kay, 1987). In 1905 the air potato was introduced to Florida and has since become an invasive species in much of the state. Its rapid growth crowds out native vegetation and is very difficult to remove since it can grow back from the tubers, and new vines can grow from the bulbils even after being cut down or burned (Schultz, 1993).

2.9.7 Cush-Cush yam (*Dioscorea trifida*)

Is native to the Guyana region of South America and is the most important cultivated “New World” yam. Since they originated in tropical rain forest conditions their growth cycle is less related to seasonal changes than other yams. Because of their relative ease of cultivation and their good flavor they are considered to have a great potential for increased production (Kay, 1987).

2.10 ANTI-NUTRITIONAL FACTORS OF YAM

The edible, matured yam does not contain any compounds however, bitter components tends to accumulate in immature tuber tissues of *Dioscorea rotundata* and *Dioscorea cayenesis*. They may be polyphenols or tannin-like compounds. Wild forms of *Dioscorea dumetorum* contain bitter compounds and alkaloid dihydrodioscorine, while that of Malayan species *Dioscorea hispida* is dioscorine. These are water-soluble alkaloids, which on ingestion produce severe and distressing symptoms (Mas-Yamaguchi, 1983).

The bitter compound of *Dioscorea bulbifera* (potato yam) induces a 3-furanosidenorditerpene called diosbulbin, which causes paralysis. Extract are used in immobilizing fish and in Malaysia, the yam is used in poisoning tigers and the extract is used in preparation of arrow-poison in Indonesia. Alkaloids Dioscorine may be used as poison and steroids derivatives e.g. diosgenin is extracted for pharmaceutical use (Ihekoronye and Ngoddy, 1985).

2.11 UTILIZATION AND PROCESSING TECHNIQUES

The processing of yam tuber is a long established practice. Traditionally, yam is prepared in several ways for immediate consumption. Yam tubers are consumed in forms of chunks, flour, chips, fufu and slices, which are obtained from any of the processes of boiling, frying, drying, fermentation, milling, pounding, roasting and steaming (Iwuoha, 2004). Raw yam flour has also found increasing use in bakery as dough conditioner in ice- cream and as thickener in soups (Iwuoha, 2004).

2.12 DRYING

At the time of harvest, most agricultural products have higher moisture content. Crops with higher moisture content after harvest deteriorate from several causes such as growth of microflora, particularly the aerobic of molds. Therefore, crops must be probably processed for long-term storage when they are in abundance at harvesting seasons, so that they can be used in the period of scarcity (Whitfield, 2000).

According to Bolaj and Nowicki (2003), drying is a process by which water is removed from a substance. The two types of water which are present in food items are the chemically bound water and the physically held water. In drying, only the physically held water is removed. The main reason for drying food items is to reduce its water content to a level where it can be safely stored for future use. Whitfield (2000) also claims that drying is an excellent way to preserve food and solar food dryers are an appropriate food preservation technology for a sustainable world. Solar food drying is one of the oldest agricultural techniques related to food preservation.

Most agricultural produce are lost through spoilage especially during the harvesting period. This is due to ignorance about preservation of produce, inadequate transportation systems during the harvest season (mostly climate related), and the low price the rural farmer receives for products during the harvest season.

2.12.1 Sun Drying

Sun-drying is done by a direct exposure of the product spread on the ground or an improvised material to sun ray, following some special prior treatment. The produce is stirred regularly until they reach a stage considered to be satisfactory by local criteria for taste, brittleness and change of colour. (Alonge and Hammed, 2007).

The main advantages of sun drying are low capital and operating costs and the fact that little expertise is required. The main disadvantages of this method include; contamination, theft or damage by birds, rats or insects, slow or intermittent drying and no protection from rain or dew that wets the product. This encourages growth of mould and may result in a product with relatively high final moisture content. Also because the temperature of the sun cannot be regulated, low and variable quality products may be produced due to over or under drying. Sun drying also tends to be laborious since the produce must be stirred regularly and also moved if it rains. Moreover, since sun drying depends on uncontrolled factors, production of uniform and standard products is not expected. (Alonge and Hammed, 2007),

2.12.2 Solar Drying

Solar dryers are specialized devices that control the drying process and protect agricultural produce from damage by insects, dusts and rain. In comparison to drying product in the open, solar dryers generate higher temperatures and lower relative humidity, and increase flow of air across the produce, resulting in shorter drying periods, lower product moisture content and reduced spoilage during the drying process (Whitfield, 2000).

The basic principle of operation is that air is heated in a collector by the greenhouse effect. The hot air then dries the produce in a drying chamber. Solar heating systems to dry food and other crops can improve the quality of the product, while reducing wasted produce and traditional fuels. Thus improving the quality of life (Whitfield, 2000).

2.12.3 Oven Drying

Drying in an oven takes place when heat is supplied to the sample by radiation from the oven walls, convection from circulating air and conduction through the tray on which the food is placed. Heat passes through the food by conduction in most cases although, convectional currents are established during the initial heating of the sample. Infrared radiation is absorbed into the food and converted to heat by interaction with molecules of the sample. Air, other gasses and moisture vapour in the oven transfer heat by convection. The heat is converted to conductive heat at the surface of the sample and the oven walls. A boundary film of air acts as a resistance to the heat transfer into the sample and to movement of water vapour from the sample. The thickness of the boundary layer is determined mostly by the velocity of the air and the surface properties of the sample. When a sample is placed in an oven, moisture at the surface is evaporated and removed by the hot air. The low humidity of air in the oven establishes moisture vapour pressure gradient which cause movement of moisture from interior of the sample to the surface. The extent of moisture loss is determined by the nature of the food and the rate of heating. When the rate of moisture loss exceeds the rate of movement from the interior, the zone of evaporation moves inside the sample, the surface dries out, its temperature rises to the temperature of the hot air (110^{O}C-240 ^{O}C) and a crust is formed (Fellows, 1992).

2.13 YAM CHIPS

Due to the incidence of very high postharvest losses, processing of yam prior to storage is an alternative for reducing those postharvest losses (Okaka and Anajekwu, 1990). Despite the fact that yam are mostly eaten in its fresh form, the processing of yam tubers into chips for domestic use has been a long time practice in all yam producing zones. This is a stabilized product obtained from small pre-cooked and sun-dried tubers. Farmers sometimes stored part of their production in their kitchens after treatment to cover the periods of scarcity. This technique involves peeling the tubers, pre-boiling them in water containing natural substances which act as fungicides and insecticides. They are dried in the sun preferably during harmattan to attain a moisture content of about 10 to 13%. However, it is not in all cases that the tubers are pre-boiled, especially in Nigeria (Ezeh, 1992). Akissoe *et al*., (2004), have also reported that quality of dried yam chips depends on pre-treatment conditions (blanching, drying methods, and size), particularly on the drying conditions. They also claim mechanical slicing of the chips can be a means to accelerate the drying process.

Small tubers weighing between 3 and 4 kg are preferred for the production of yam chips because they dry more easily, and are consequently considered by consumers to be of better quality. The two most commonly used varieties of yam for yam chips production are *Dioscorea cayenensis* and *Dioscorea rotundata* (Vernier *et al*., 1997). They also claim that, yam chips are mainly eaten in paste form, also known as 'amala' especially in Nigeria and it is prepared from the flour obtained by grinding them. The yam chips derivatives are mostly eaten because of its taste, availability, and ease of preparation.

Plate 2.5: Fresh yam chips

2.14 IMPORTANCE OF YAM CHIPS

According to Vernier *et al.,* (1997), processing of yam into yam chips makes it possible to stabilize the product, thereby reducing considerably postharvest losses. Yam chips can be preserved for over a year, and are therefore regularly available on the urban market. The transportation cost per dry unit is much less since the dried chips contains lower moisture content than the fresh tuber. Yam chips can also offer opportunities for cooking, for example the possibility of processing the flour into granules or incorporating it in starchy products like biscuits, baby food, beverages.

2.15 PROBLEMS ENCOUNTERED DURING YAM CHIPS PRODUCTION

Vernier *et al.,* (1997), claimed that sun dried yam chips are normally of poor quality because it takes a longer period for the chips to dry which is not the case during the harmatan season due to the low relative humidity. This result in the production of yam chips that are poorly dried resulting in darkening. Also during storage, the chips are often infested by boring insects which cause considerable damage in a few months. The most common among these insects are *Sitophilus zeamais*, *Dinoderus oblonguntatus*, D. *minutus Fabricius* and *Palorus subdepressus*.

2.16 YAM FLOUR

The yam flour production from fresh tuber soon after harvest serves as an effective procedure against storage loss. The yam tubers are washed, weighed and peeled under running water to prevent enzymatic browning and the tubers are cut into thin slices for fast drying. The dried slices are grounded into flour using a wooden mortar and pestle, then the use of motor driven milling machine into fine texture and repeatedly sieved to remove any lumps. (Ekwu, 2003). The resulting product is a white to cream flour, which can be stored for months. The storage environment must be dry to prevent the growth of moulds and must be well protected from weevils, which may infest the dried products (Ige and Akintunde, 1981).

Plate 2.6: Yam flour samples

3.0 MATERIALS AND METHOD

3.1 FIELD SURVEY

A preliminary survey was conducted to sample views of retailers and producers in areas with much yam production in the Ashanti and Brong Ahafo Region. Information gathered from the Ministry of Food and Agriculture, Kumasi Regional and District offices, together with the outcome of the preliminary survey were used in identification of markets and districts with substantial yam production activity within the regions. On the basis of this, five markets in the Kumasi metropolis were selected for gathering information from the yam sellers. On the other hand yam farmers were randomly selected and interviewed in the Techiman district. The survey was conducted between February to May, 2012 to gather relevant information from the areas identified.

3.1.1 Questionnaire Design

A semi-structured questionnaire was used to access the required data needed. Information solicited in the questionnaire included yam varieties, uses of each variety, farming and postharvest practices carried out on the farms and markets investigated included sources of yam and storage facilities.

3.1.2 Sampling Area

Sampling was done in the five selected markets and one district namely; Krofrom (Moro), Central (Bode), Abinchi, Asafo, Bantama, all in the Kumasi Metropolis of the Ashanti Region and the Techiman district in the Brong Ahafo Region. Areas with high yam production and retailing were identified and used as sampling locations.

3.1.3 Questionnaire Administration

Individual interviews were carried out. Semi-structured questionnaires were administered to traders and farmers engaged in yam production. Trader selection was based on those who sold yam and markets were selected of being known as yam markets. The farmer selection was based on those who cultivated only yam. A total of fifty (50) semi-structured questionnaires were administered to the traders and twenty (20) to the farmers from the selected sampling location within the five selected markets and one selected district.

3.1.4 Statistical Analysis

Data collections from all sampling locations were subjected to statistical analysis using the Statistical Package for the Social Scientist (SPSS) version 16. Descriptive statistics were statistical tools employed in the analysis. The data output were presented in the tables and graphs (pie charts and bar graphs) with values presented in percentages.

3.2 LABORATORY EXPERIMENTS

3.2.1 Location of Experiment

The laboratory experiments were carried out in the Department of Horticulture, Faculty of Agriculture, Institute of Renewable Natural Resources, KNUST and Food Research Institute (FRI) of the Council for Scientific and Industrial Research (CSIR), Accra between April to July,2012.

3.3 METHOD

3.3.1 Preparation of yam chips and flour

Yam flour was produced using the process described by Babajide *et al*., (2006) depicted in Figure 2.1. The fresh yam tubers were thoroughly washed under water to remove any adhering soil and other undesirable materials from the yam. Peeling was done with a sharp knife and the peeled yams were sliced into sizes of about 2cm in thickness. A kilogram of chips of each yam variety was weighed with an electronic scale then dried by means of sun, solar and oven. The samples were weighed at regular intervals until a constant weight was obtained then grounded into flour. The flour was then passed through a 0.5mm mesh size and stored in airtight containers until needed for analysis.

Washing

↓

Peeling

↓

Slicing (2-3cm thickness)

↓

Draining

↓

Solar Drying + Sun Drying + Oven drying (70^{O}c)

↓

Dry yam chips

↓

Milling

↓

Sieving

↓

Yam flour

(Babajide *et al*, 2006)

Figure 3.1: Flow chart showing Production of Yam Flour

3.4 PROXIMATE COMPOSITION STUDIED

3.4.1 Proximate Analysis

Each flour sample was analyzed for moisture content which was determined according to method 964.22; crude protein was determined using the Kjeldahl method; crude fat extracted in a Soxhlet extractor with hexane and quantified gravimetrically; ash according to method 923.03[19]. Crude fibre was determined using the method described by AOAC (2005). Carbohydrate was calculated by difference.

3.4.1.1 Moisture Content

The Moisture Content was determined using procedure described by AOAC (2005). The moisture content of each sample was determined by weighing 5g of the sample into an aluminum moisture can. The sample was then dried to constant weight at 105±2C.

$$\text{Moisture content} = \frac{(\text{Weight of can} + \text{sample}) - (\text{weight of empty can}) \times 100}{\text{Weight of sample}}$$

3.4.1.2 Determination of Crude Protein

The Protein Content was determined using a Foss Tescator protein digestor and KJECTEC 2200 distillation apparatus (Kjeldahl method) according to the procedure of AOAC (2005). Concentrated H_2SO_4 (12ml) and 2 tablets of catalyst were put into a Kjeldahl digestion flask containing 1g of the sample. The flask was placed in the digestor in a fume cupboard and switched on and digestion was done for 45 minutes to obtain a clear colorless solution. The digest was distilled with 4% boric acid, 20% Sodium hydroxide solutions were automatically metered into it in the KJECTEC 2200 distillation equipment until distillation was completed. The distillate was then titrated with 0.1M HCl until a violet color formation indicating the end point. A blank was run under the same condition as with the sample. Total nitrogen content was then calculated according to the formula:

$$\text{Crude Protein} = \frac{(\text{Titre value (of sample)} - \text{blank}) \times 0.01 \times 14.007 \times 6.25 \times 100}{1000 \times \text{Weight of sample}}$$

3.4.1.3 Determination of Crude Fat Content

Crude fat was extracted in a Soxhlet extractor with hexane and quantified gravimetrically. 1g of sample was weighed into an extraction thimble and then stopped with grease-free cotton. Before extraction commenced the round bottom cans was dried, cooled and weighed. The thimble was placed in extraction chamber and 80ml hexane was added to extract the fat. The extraction was carried out at 135^{0}C, lasted for 1hour 40minutes after which the fat collected in the bottom cans were cooled in a desiccator.

$$\text{Crude Fat} = \frac{\text{Weight of fat} \times 100}{\text{Weight of sample}}$$

3.4.1.4 Determination of Crude Fiber

2g of the sample was transferred into 1 litre conical flask litre. 100ml of sulphuric acid (12.5M) was heated to boiling and then introduced into the conical flask containing the sample. The contents were then boiled for 30 minutes ensuring that the level of the acid was maintained by addition of distilled water. After 30 minutes, the contents were then filtered through a muslin cloth held in a funnel. The residue was rinsed thoroughly until its washing was no longer acidic to litmus. The residue was then transferred into a conical flask. 100ml of sodium hydroxide (12.5M) was then brought to boil and then introduced into the conical flask containing the sample. The contents were then boiled for 30 minutes ensuring that the level of the acid was maintained by addition of distilled water. After 30 minutes, the contents were then filtered through a muslin cloth held in a funnel. The residue was rinsed thoroughly until its washing was no longer alkali. The residue was then introduced into an already dried crucible and ashed at

600℃ ±200℃

$$\text{Crude Fiber} = \frac{\text{Final Weight of Crucible} - \text{Initial weight of crucible} \times 100}{\text{Weight of Sample}}$$

3.4.1.5 Determination of Ash Content

2g of samples were weighed into well incinerated crucibles and then burnt into ash in a muffle furnace at 600^{0}C for 3 hours. The ash content was calculated as

$$\text{Ash Content} = \frac{\text{Weight of Ash} \quad \times 100}{\text{Weight of sample}}$$

3.4.1.6 Determination of Nitrogen-Free Extract

The calculation of nitrogen-free extract (NFE) is made after completing the analysis for crude ash, crude fat, crude protein, ash. The calculation is made by adding the percentage values on dry basis of these analysed contents and subtracting them from 100%.

3.5 FUNCTIONAL PROPERTIES STUDIED

3.5.1 Functional Properties

Functional properties: bulk density, water and oil absorption capacity, swelling power and solubility, foam capacity and stability and gelation capacity.

3.5.2 Bulk density

Using the procedure of Okaka and Potter (1979), 50 g of yam flour was put into a 100 ml measuring cylinder and tapped to a constant volume and the bulk density (gcm-3) calculated using the formula:

Bulk density = weight of flour (g) / flour volume (cm3).

3.5.3 Water and oil absorption capacities

1g of yam flour was mixed with 10 ml distilled water or refined palm oil (frytol) in a pre-weighed 20 ml centrifuge tube. The slurry was agitated for 2 min, allowed to stand at 28°C for

30 min and then centrifuged at 500 rpm for 20 min. The clear supernatant was decanted and discarded. The adhering drops of water or oil in the centrifuge tube were removed with cotton wool and the tube was weighed, the weight of water or oil absorbed by 1 g of flour or protein was calculated and expressed as water or fat absorption capacity (Beuchat, 1977).

3.5.4 Foam capacity and stability

1g of yam flour was whipped with 100 ml distilled water for 5 min in a Kenwood blender at 500 rpm and poured into a 250ml graduated cylinder. The volume of foam at 30 sec after whipping was expressed as the foam capacity and the volume of the foam after 60 min as the stability for the respective time periods. Foam stability was determined at 0, 30, 60 and 90 min after whipping as described by Chinma et al. (2008).

3.5.5 Swelling power

This was determined as described by Leach et al. (1959). 1g of the yam flour was mixed with 10 ml distilled water in a centrifuge tube and heated in a hot water bath at 80°C for 30 min while continuously shaking the tube. After heating, the suspension was centrifuged at 1000 g for 15 min. The supernatant was decanted and the weight of the paste taken. The swelling power was calculated as:

Swelling power = weight of the paste / weight of dry flour.

3.5.6 Gelation Capacity

This was done by the method of Coffman and Garcia (1977). Sample suspensions 2-20% (w/v) will be prepared in 5 ml distilled water. The tubes containing the suspensions will be heated in boiling water. The tubes were then cooled for 2 hours at $7^{O}C$. The least gelation concentration (LCG) will be determined at that concentration when the samples from the inverted tube do not fall or slip.

3.5 7 Pasting Characteristics

A smooth paste was made of the prepared flours (40g) in 420ml distilled water (8.8% slurry) for viscoelastic analysis using Brabender Viscoamylograph (Viskograph-E, Brabender Instrument Inc. Duisburg, Germany) equipped with a 1000cmg sensitivity cartridge. The smooth paste was heated at a rate of $1.5°Cmin^{-1}$ to 95°C and maintained for 15min. It was then cooled at $1.5°Cmin^{-1}$ to 50°C and maintained for 15min. Viscosity profile indices were recorded for pasting temperature, peak temperature, peak viscosity, viscosity at 95°C,viscosity after 15min hold at 95°C(95°C Hold), viscosity at 50°C, viscosity after 15min hold at 50°C(50°C Hold), breakdown and setback as described by Mazaurs, et al, (1957) and Walker, et al, (1988).

3.5.8 Colour Determination

Tristimulus reflectance colorimetry was measured to assess the extent of colour changes in the flours after processing and during storage using a Minolta Chroma Meter Model CR 310(Minolta Camera Co. Ltd., Osaka, Japan). The Yxy tristimulus values measured were transformed into CIE colour space coordinates L*, a*, b*(Anon, 1976). The CIELAB Colour parameters L*, a*, b.*

The colour of the flour was determine using the colour meter (Chromameter).The L, a, b measurements are based on the following. The L axis indicates Lightness/darkness on a scale of 100. The a axis indicates Red(+ve values)/Green(-ve values) and the b axis indicates Yellow(+ve values)/Blue(-ve values).

The instrument was standardized each time with a ceramic plate. All colours that can be Perceived visually can be measured in any L*, a*, b.* scale. These scales can also measure the color difference between a sample and a standard. Color difference is always calculated as SAMPLE minus STANDARD and is frequently stated with a Δ symbol.

- If ΔL is positive, then the sample is lighter than the standard. If negative, it would be darker than the standard.

- If Δa is positive, then the sample is more red (or less green) than the standard. If negative, it would be more green (or less red).

- If Δb is positive, then the sample is more yellow (or less blue) than the standard.

3.6 EXPERIMENTAL DESIGN

A Randomize Complete Block Design (RCBD) was the experimental design used. Experiments were replicated three times. The flour developed served as the experimental treatments.

3.7 STATITICAL ANALYSIS

All data collected were subjected to statistical analysis using Analysis of Variance (ANOVA), Genstat statistical package version 5 was used. Testing for differences between means was at 5% level (P = 0.05).

4.0 RESULTS

4.1 INTRODUCTION

This chapter presents the findings of the study and reports the responses of respondents; comprised of yam retailers and producers randomly selected from the markets and district. A total of 50 retailers and 20 producers were interviewed to ascertain their background information, production practices, postharvest techniques employed and the general knowledge on yam and yam flour. It also contains results of proximate, functional and pasting. Essentially, this chapter outlines and analyses the findings of the study by presenting the data with graphs (bar and pie charts) and tables.

4.2 FIELD SURVEY

4.2.1 Background Information on Retailers and Producers

Data on sex of the respondent in the markets for the retailers showed that females dominated in all the markets while males dominated with that of the producers with (80.0%) against (20%) of the females. However in the Asafo and Bantama markets, respondents interviewed were all females (100%). In the rest of the markets, males came second to females in retailing (Figure 4.1,

4.2).

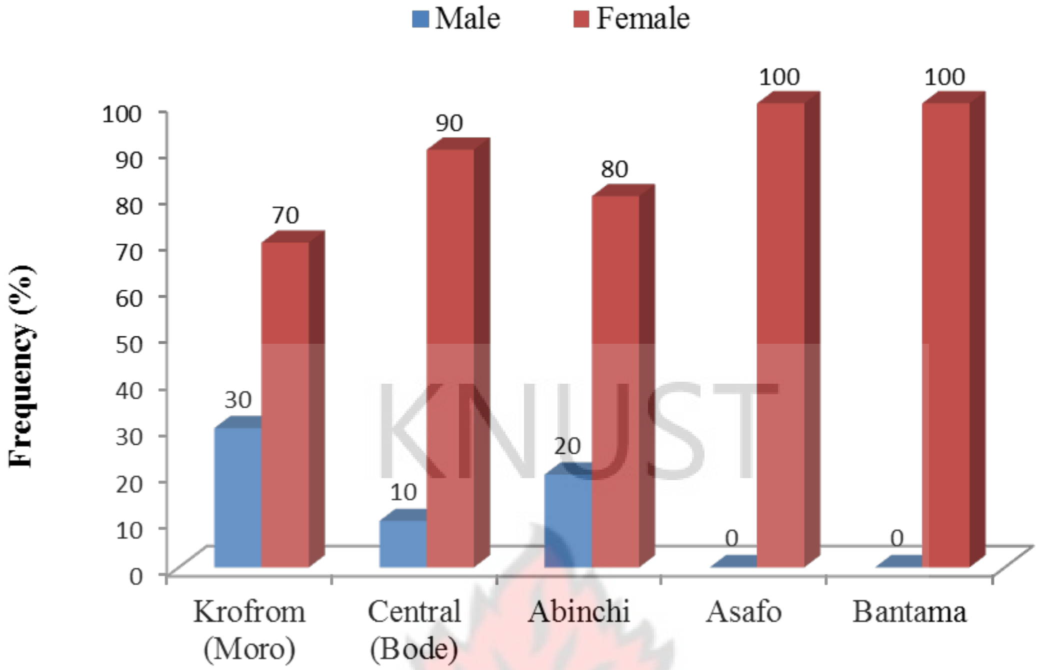


Figure 4.1: Gender of Retailer Respondents

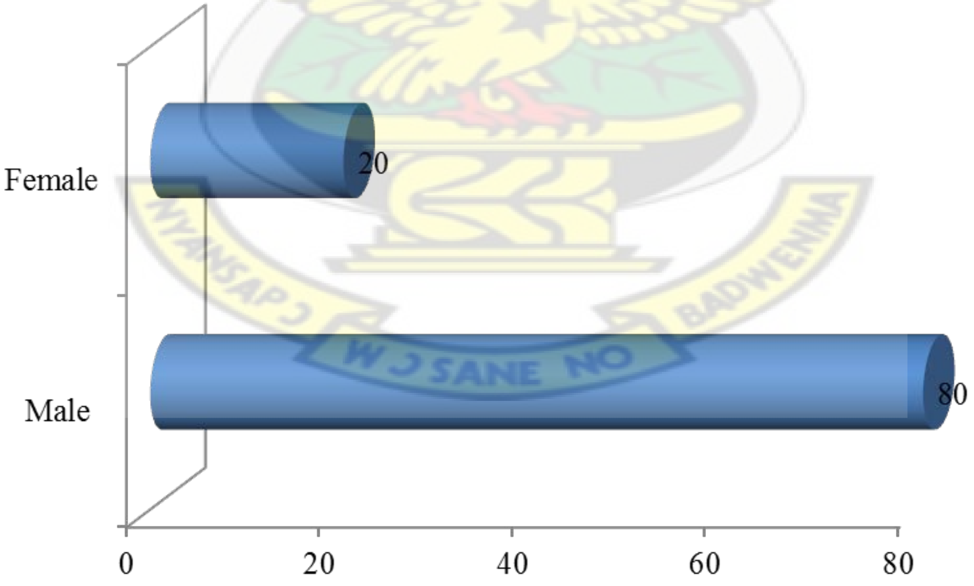


Figure 4.2: Gender of Producer Respondents

Age distribution differed from market to market so as in the district as indicated in Table 4.1, 4.2 below. Majority of the respondents for the retailers were in the range of 40-50 years (46.0%), 30-40 years (32.0%), 20-30 years (18.0%), 50 years and above (4.0%) while 0% were in the range of 20 years and less. Retailers in the Asafo market (5), Central market (5) and Moro market (7) age ranged from 40 – 50 years respectively. Retailers in Abinchi market (7) were aged between 20 – 30 years. In the Bantama market, 6 of the retailers were aged between 30 – 40 years.

Majority of the respondents for the producers were in the range of 30 – 40 years (40%), 40 – 50 years (30%), 50 years and above (25%) and 20 – 30 years (5%). There were no respondents recorded for the age range of 20 years and less.

Table 4.1: Age distribution of Retailers

Age Range (Years)

Market	< 20	20 - 30	30 - 40	40 - 50	> 50	Total	Mean
Krofrom	0	30	40	20	10	100	31.7
Central	10	40	20	20	10	100	28.9
Abinchi	15	35	12	18	20	100	29.2
Asafo	0	40	45	5	10	100	32.6
Bantama	15	45	25	10	5	100	30.4

Table 4.2: Age distribution of Producers

	Age Range (Years)						
Area	< 20	20 - 30	30 - 40	40 - 50	> 50	Total	Mean
Tanoso (Techiman)	0	15	40	35	10	100	40.27

On the level of education, majority of the retailers interviewed had no formal education (73%), 23% had formal or basic education to the JHS level, 4% had secondary education while none had tertiary education. Krofrom (Moro) market recorded the highest in Informal education (90%) respectively. Central (Bode) market on the other hand recorded the highest in basic education (60%). Asafo market recorded the highest in secondary education (15%). None of the respondents in all the markets had tertiary education.

Producers in the Tanoso district of Techiman municipality had 65% recorded for Informal education, 15% recorded for basic education, 10% recorded for secondary education and 10% again was recorded for tertiary education.

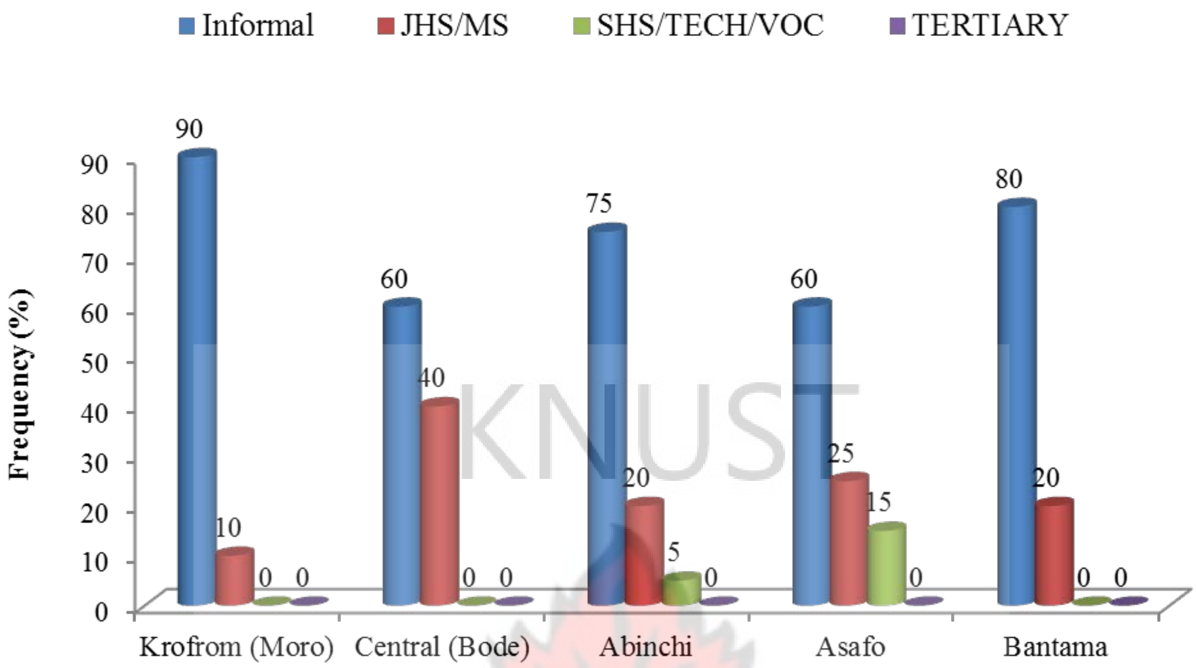


Figure 4.3: Educational Background of Retailers

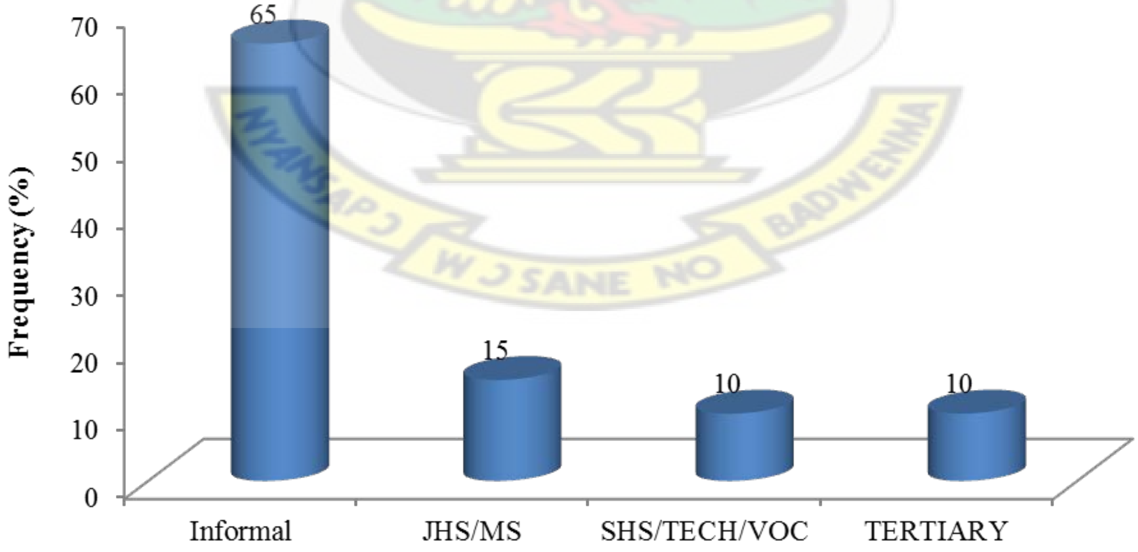


Figure 4.4: Educational Background of Producers

4.2.2 Production Practices Carried Out

Sources of yam for the retailers mainly do come from farming centers through the country, the highest producing center is in the northern region of Ghana, followed by the Brong Ahafo Region then the others. Varieties produced depends on the production areas thus different production centers produces different varieties. A few of the retailers said they produce the yam themselves and bring them to the markets to sell.

According to the retailers interviewed, yam is an all season crop, its major season is around July to January and its minor season around February to June.

From Figure 4.5 and 4.6, Pona cultivar dominated in both the market centers and production area with 42% and 35% for both retailers and producers respectively. Labreko cultivar recorded 7% and 15% for retailers and producers respectively while Dente cultivar recorded 18.6% and 10% for retailers and producers respectively. 16% and 5% was recorded for Asobayire for both retailers and producers. Dokoba for retailers was 10.4% and that of producers was 15%. Retailers recorded 6% for muchmudu and producers recorded 6% also for muchumudu. Bayirefitaa was found in the Tanoso producing area and it recorded 15%. Pona, Labreko and Dente recorded the highest varieties based on the survey.

Cultivars producred is based on a number of reasons mainly high demands, high quality, high price and low price. Basically the high quality and high demand reasons remain the most important but the sizes do matter a lot in terms of the prices.

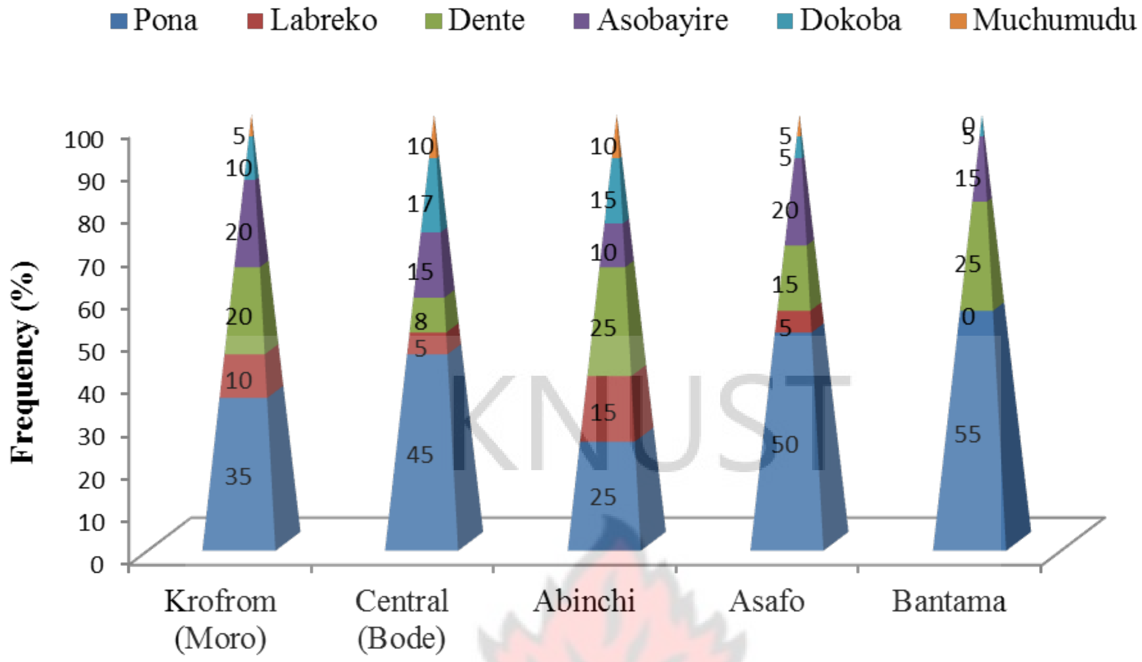


Figure 4.5: Cultivars of yam sold by the Retailers

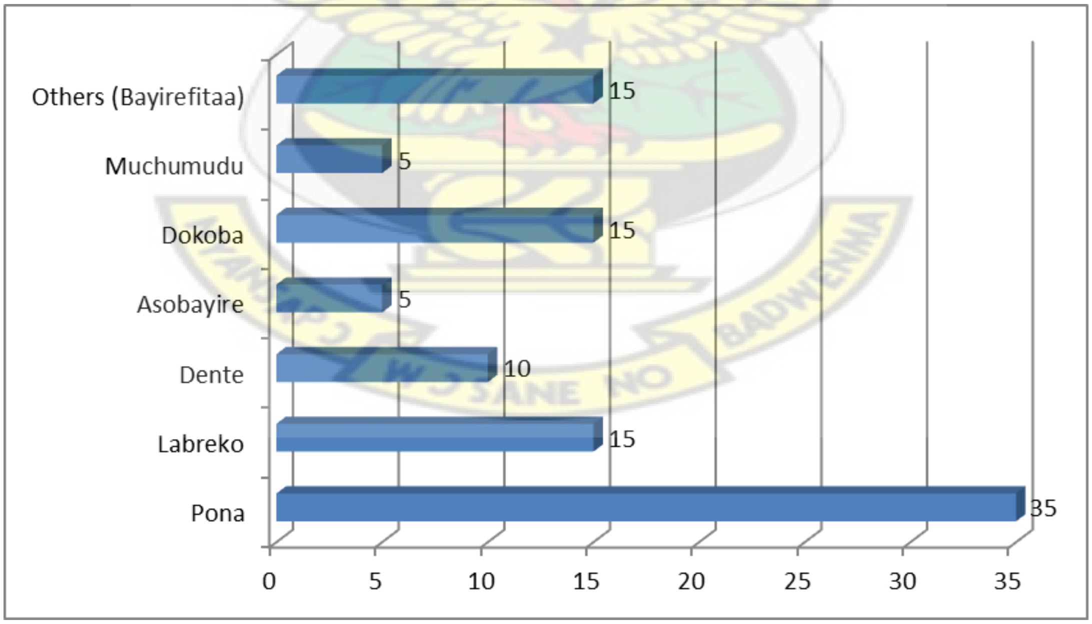


Figure 4.6: Cultivars of yam sold Produced in the Tanoso District

4.2.3 Knowledge on Flour Production

Yam has a lot of uses which includes food, processing, feed for animals and others but from the survey, most of the respondents reported that yam was mainly used as food. It can be boiled, fried, roasted, etc.

Yam can also be processed into other food products like flour, chips, pudding etc. However, Yam flour is not a very common product in this country. Some respondents said it was common in some parts of the northern region and others parts in the Brong Ahafo Region. This was so because people preferred cassava flour to yam flour. Both are used to prepare an important delicacy or food known as 'kokonte'.

Sun drying was a very common method of drying used in drying the yam, this was because of its neasiness and sun's availability.

From Figure 4.5 and 4.6, not all varieties are used for 'fufu' preparation. Pona dominated in both retailers and producers recording 90% and 85% respectively. Labreko, Dente are used but not commonly used.

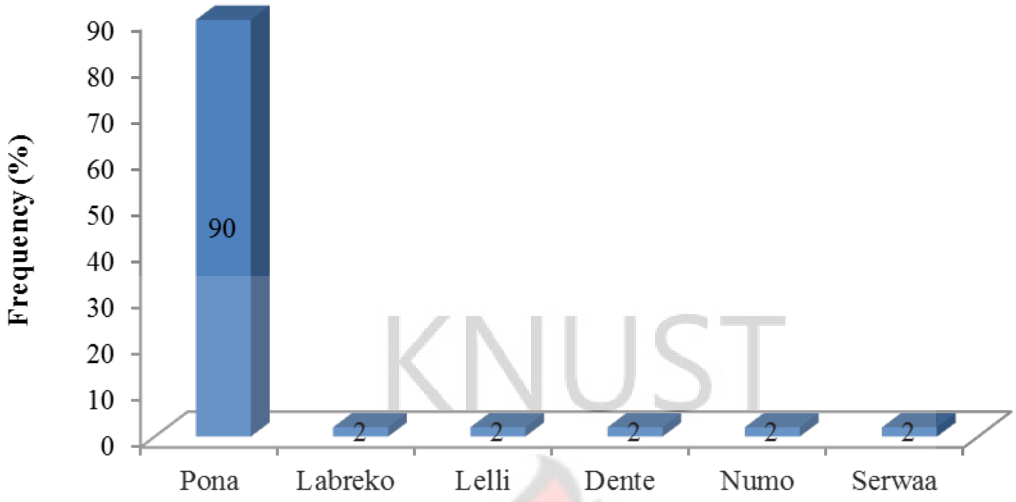


Figure 4.7: Cultivars of yam used for fufu by the Retailers

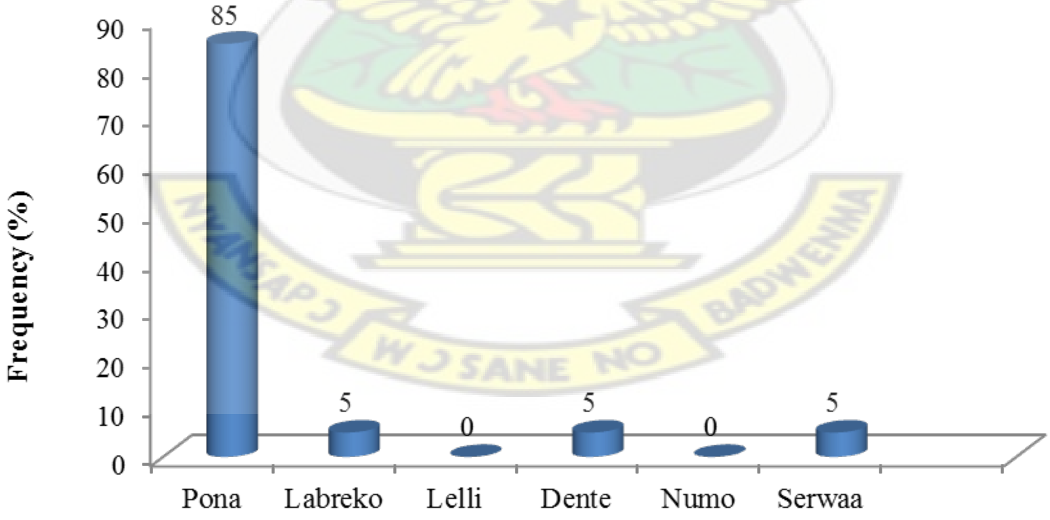


Figure 4.8: Cultivars of yam used for fufu by the Producers

4.2.4 Post Harvest Handling

Yams brought to the markets were not immediately purchased due to the quantity and the demand at the time. They are mainly stored and re sold later. Storage in yam in the markets take many forms such as packed in a room, buried in the soil and packed under shade. Most of the respondents packed them in a room and on slabs of wood.

Losses occurred during storage and this was caused by rotten tubers, holes bore by pests and infections caused by various diseases and these do affect sales.

4.3 Temperature and Humidity Records

The experiment was conducted in the dry season which was associated with high temperatures and low relative humidity. Figure 4.3.1, 4.3.2 and 4.3.3 shows the temperature and relative humidity values together with the average time taken for samples to dry under the various drying methods. As well as cumulative percentage weight loss.

Oven drying recorded the quickest drying time of 2 days while both Sun and Solar drying recorded took 5 days to dry.

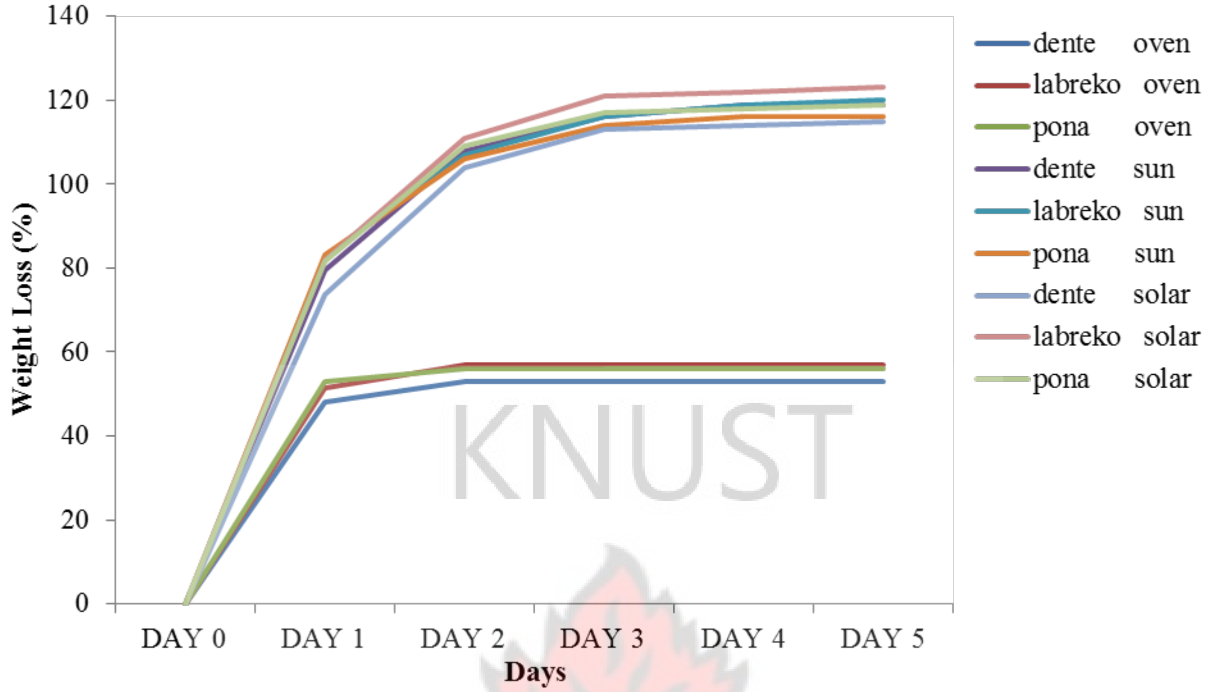


Figure 4.9: Cumulative Percentage Weight loss of yam chips with time

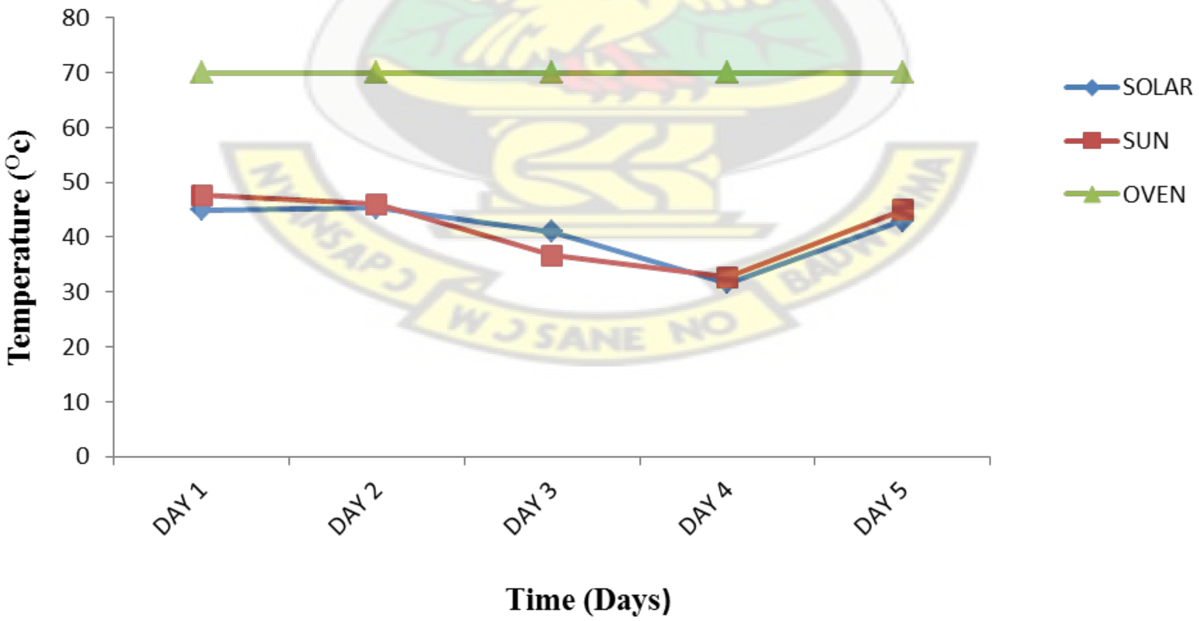


Figure 4.10: Temperature 0f Drying Environment over Time

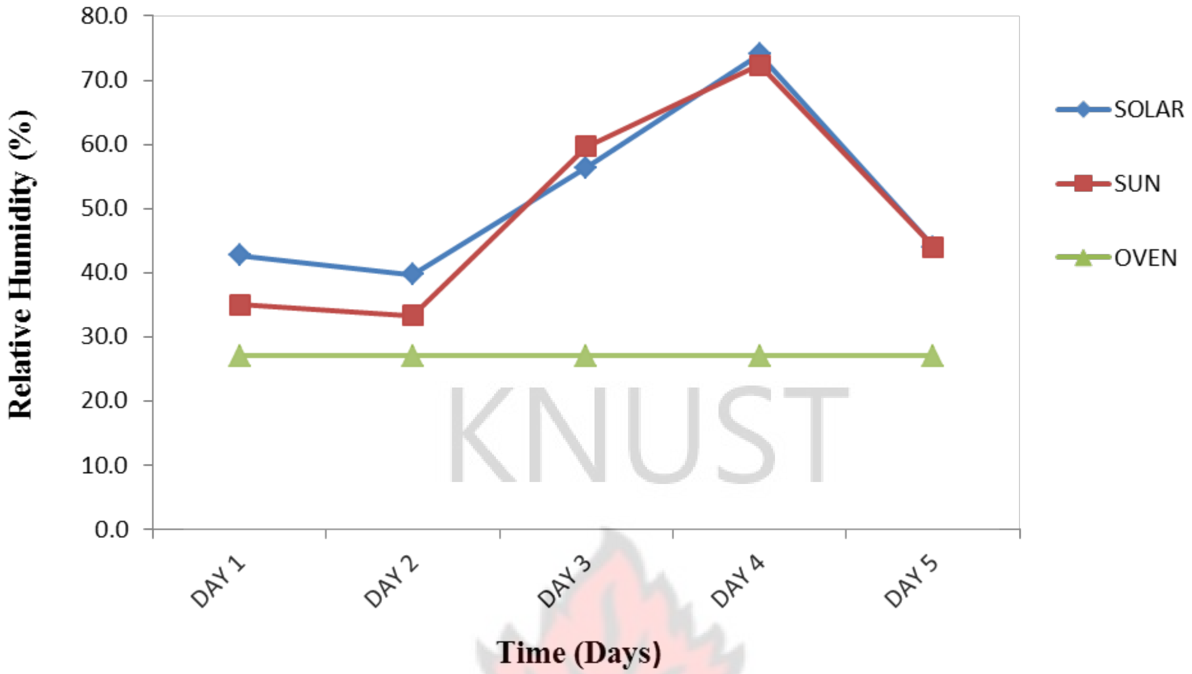


Figure 4.11: Relative Humidity of dying Environment over time

4.4 FUNCTIONAL PROPERTIES

4.4.1 Bulk Density

There were no significant differences ($p>0.05$) between the yam varieties in terms of Bulk Density where mean values were all 0.83g/ml.

The mean values for the drying methods ranged from 0.84g/ml to 0.82g/ml. Oven dried samples recorded the highest (0.84g/ml) followed by solar dried samples (0.83g/ml) with Sun dried samples recording the least (0.82g/ml) Bulk density however these variations where statistically different from each other ($p<0.05$).

The interaction effect of the yam varieties and drying method show some significant differences ($p<0.05$). Oven dried Pona and Labreko both recorded the highest Bulk Density of 0.85g/ml which was statistically different from that of Solar dried Pona, Sun dried Pona, Sun dried Dente and Sun dried Labreko with value of 0.82g/ml, 0.82g/ml, 0.83g/ml and 0.81g/ml respectively. However it was not statistically different from Oven dried Dente, Solar dried Dente, and Solar dried Labreko with values of 0.83g/ml, 0.84g/ml and 0.83g/ml respectively.

Sun dried Labreko recorded the least Bulk Density value of 0.81g/ml which was significantly different from all the samples.

4.4.2 Water Absorption Capacity

There were no significant differences ($p>0.05$) between the yam varieties in terms of water absorption capacity where mean values ranged between 8.44ml/g to 8.35ml/g with Labreko recording the highest mean value 8.44ml/g and Dente recording the least of 7.94ml/g.

The mean values for the drying methods ranged from 8.33ml/g to 8.19ml/g. Oven dried samples recorded the highest (8.33ml/g) followed by solar dried samples (8.26ml/g) with Sun dried samples recording the least (8.19ml/g) water absorption capacity. However, these variations where not statistically different from each other ($p>0.05$).

The interaction effect of the yam varieties and drying methods showed some significant differences ($p<0.05$). Oven dried Pona and Labreko recorded the highest water absorption capacity of 8.60ml/g which was statistically different from that of sun dried Dente (8.07ml/g), solar dried Dente(7.97ml/g), Oven dried Dente (7.80ml/g), however it was not statistically different from sun dried Pona (8.10ml/g), solar dried Pona (8.47ml/g), sun dried Pona (8.40ml/g) and solar dried Labreko (8.33ml/g).

Oven dried Dente recorded the Least Water Absorption capacity value of 7.80ml/g which was not significantly different from Solar dried Dente (7.97ml/g), Sun dried Dente (8.07ml/g) and sun dried Pona (8.10ml/g).

4.4.3 Oil Absorption

There were significant differences ($p<0.05$) between the yam varieties in terms of Oil Absorption Capacity where mean values ranged between 9.08ml/g to 8.88ml/g. Labreko recorded the least of 8.87ml/g which was significantly different from Pona (9.07ml/g) and Dente (9.04ml/g).

The mean values for the drying methods ranged from 9.01ml/g to 8.99ml/g with sun dried samples recording the highest (9.01ml/g) followed by Solar dried samples (9.00ml/g) and sven dried samples recording the least (8.99ml/g) Oil Absorption Capacity, however these variations where not statistically different from each other ($p>0.05$).

The interaction effect of the yam varieties and drying method show some significant differences ($p<0.05$). Sun dried Labreko recorded the Least Oil Absorption Capacity of 8.73ml/g which is statistically different from the other samples except oven dried Labreko (8.93ml/g) which was not significantly different.

Sun dried Pona recorded the highest Oil Absorption Capacity value of 9.17ml/g which was significantly different from Sun dried Labreko (8.73ml/g) and Oven dried Labreko (8.93ml/g).

4.4.4 Swelling Power

There were significant differences ($p<0.05$) between the yam varieties in terms of Swelling Power where mean values ranged from 5.57g/ml to 4.32g/ml. Labreko recorded the highest with 5.57g/ml which was significantly different from Dente (4.32g/ml).

The mean values for the drying methods ranged from 5.02g/ml to 4.69g/ml. Sun dried samples recorded the highest (5.02g/ml) followed by oven dried samples (4.70g/ml) with solar dried samples recording the least (4.69g/ml). These variations where statistically different from each other (p<0.05).

The interaction effect of the yam varieties and drying method showed some significant differences (p<0.05). Oven dried Pona recorded the Least Swelling Power of 3.57g/ml which statistically differed from that of sun dried Labreko and oven dried Labreko with value of 6.33g/ml and 5.60g/ml respectively. However, it was not statistically different from the other samples.

Sun dried Labreko recorded the highest Swelling Power value of 6.33g/ml which was significantly different Oven dried Pona (3.57g/ml), sun dried Dente (3.80g/ml) and solar dried Dente (4.23g/ml).

4.4.5 Solubility

There were no significant differences (p>0.05) between the yam varieties in terms of Solubility where mean values ranged between 6.79g/ml to 5.72g/ml with Labreko recording the highest mean value 6.79g/ml and Pona recording the least of 5.72g/ml.

The mean values for the drying methods ranged from 5.02g/ml to 4.70g/ml with Sun dried samples recording the highest (5.02g) followed by Oven dried samples (4.70g/ml) and Solar dried samples recording the least (4.69g/ml) Solubility however these variations where not statistically different from each other (p>0.05).

The interaction effect of the yam varieties and drying method show some significant differences ($p<0.05$). Oven dried Pona recorded the Least Solubility of 3.57g/ml which is statistically different from that of Sun dried Labreko (6.33g/ml), Oven dried Labreko (5.60g/ml) however it was not statistically different from Sun dried Pona (4.33g/ml), Solar dried Pona (5.07g/ml), Sun dried Dente (3.80g/ml), Solar dried Dente (4.23g/ml), Oven dried Dente (4.93g/ml) and Solar dried Laberko (4.77g/ml).

Sun dried Labreko recorded the highest Solubility value of 6.33g/ml which was significantly different from Sun dried Pona (4.33g/ml), Oven dried Pona (3.57g/ml), Sun dried Dente (3.80g/ml) and Solar dried Dente (4.23g/ml).

4.4.6 Foaming capacity

There were no significant differences ($p>0.05$) between the yam varieties in terms of foaming capacity where mean values ranged between 52.78ml/g to 48.00ml/g with Pona recording the highest mean value 52.78ml/g and Dente recording the least of 48.00ml/g.

The mean values for the drying methods ranged from 56.44ml/g to 50.00ml/g. Oven dried samples recorded the highest (56.44ml/g) followed by solar dried samples (51.78ml/g) with oven dried samples recording the least (50.00ml/g) forming capacity however these variations where not statistically different from each other ($p>0.05$).

The interaction effect of the yam varieties and drying method show some significant differences ($p<0.05$). Sun dried Dente recorded the least foaming capacity of 37.33ml/g statistically different from that of Sun dried Pona, Sun dried Labreko, Solar dried Labreko, Oven dried Labreko and Oven dried Dente with value of 56.67ml/g, 56.00ml/g, 55.33ml/g, 61.00ml/g, and 55.00ml/g respectively however it was not statistically different from Solar dried Pona (48.33ml/g), Solar dried dente (51.67ml/g), Oven dried Pona (53.33mi/g).

Oven dried Labreko recorded the highest foaming capacity value of 61.00ml/g which was significantly different from Sun dried Dente (37.33ml/g).

4.4.7 Foaming Stability

There were no significant differences (p>0.05) between the yam varieties in terms of foaming stability. Mean values ranged between 36.97ml/g for Dente which recorded the least to 40.19ml/g for Pona recording the highest mean value.

The mean values for the drying methods ranged from 35.99ml/g to 41.09ml/g. Sun dried samples recorded the highest followed by solar dried samples with oven dried samples recording the least forming stability however these variations where not statistically different from each other (p>0.05).

The interaction effect of the yam varieties and drying method showed some significant differences (p<0.05). Solar dried labreko recorded the least foaming stability of 24.10ml/g statistically different from that of Solar dried Pona, and Sun dried larbreko with value of 51.87ml/g and 54.60ml/g respectively however it was not statistically different from Sun dried

Pona (28.10ml/g), oven dried dente (33.47ml/g), oven dried labreko (33.90mi/g), solar dried dente (36.87ml/g) and oven dried Pona (40.60ml/g).

Solar dried Pona recorded the highest foaming stability value of 51.87ml/g which was significantly different from Sun dried Pona (28.10ml/g) and Solar dried labreko (24.10ml/g).

4.4.8 Least Gelation Concentration

The least gelation concentration of the dried yams ranged between 0.7 to 0.8 for Pona, 0.6 to 0.8 for Labreko and 0.4 to 0.8 for Dente. The least gelation concentration observed in the sun-dried yam flours for the Labreko cultivar was significantly lower ($P < 0.05$) than sun and solar-dried. Also the least concentration observed in the Solar and Sun-dried yam flours for Dente cultivar was significantly lower ($P < 0.05$) than sun and oven-dried.

Sun and Solar drying for Dente resulted in the lowest least gelation capacity (0.4) whereas solar-dried of Solar dried Pona, Oven-dried Labreko and Oven dried Dente resulted in the highest least gelation capacity (0.8).

Table 4.6: Effect of drying method and cultivar on the least gelation concentration of yam under sun-dried

Concentration	0.1	0.2	0.3	0.4	0.5	0.6	0.7	0.8	0.9	1.0	LGC
Pona	NV	NV	NV	V	V	V	G	G	G	G	0.7
Labreko	NV	NV	NV	V	V	G	G	G	G	G	0.6
Dente	NV	V	V	V	G	G	G	G	G	G	0.4

NV – Not Viscous V – Viscous G – Gel LGC – Least Gelation Concentration

Table 4.7: Effect of drying method and cultivar on the least gelation concentration of yam under solar-dried

Concentration	0.1	0.2	0.3	0.4	0.5	0.6	0.7	0.8	0.9	1.0	LGC
Pona	NV	NV	NV	NV	V	V	V	G	G	G	0.8
Labreko	NV	NV	V	V	V	G	G	G	G	G	0.6
Dente	NV	V	V	G	G	G	G	G	G	G	0.4

NV – Not Viscous V – Viscous G – Gel LGC – Least Gelation Concentration

Table 4.8: Effect of drying method and cultivar on the least gelation concentration of yam under oven-dried

Concentration	0.1	0.2	0.3	0.4	0.5	0.6	0.7	0.8	0.9	1.0	LGC
Pona	NV	NV	NV	V	V	V	G	G	G	G	0.7
Labreko	NV	NV	NV	NV	NV	V	V	G	G	G	0.8
Dente	NV	NV	NV	NV	V	V	V	G	G	G	0.8

NV – Not Viscous V – Viscous G – Gel LGC – Least Gelation Concentration

4.5 PROXIMATE ANALYSIS

4.5.1 Moisture

The mean values for the drying methods ranged from 11.78% to 9.33% with Sun dried samples recording the highest (11.78%) followed by Solar dried samples (9.33%) and Oven dried samples recording the least (5.56%) Moisture, however these variations where statistically different from each other ($p<0.05$).

There were significant differences ($p<0.05$) between the yam varieties in terms of Moisture where mean values ranged between 10.00% to 9.78%. Dente recorded the highest mean of 10.00% which was significantly different from Pona (6.89%) but not different from Labreko (9.78%).

The interaction effect of the yam varieties and drying method show some significant differences ($p<0.05$). Oven dried Pona recorded the Least Moisture of 4.00% which is statistically different from the other samples except.

Sun dried Dente recorded the highest moisture of 13.33% which was not significantly different from Sun dried Labreko (12.67%) but significantly different from the other samples.

4.5.2 Ash

There were no significant differences ($p>0.05$) between the drying methods where mean values ranged from 2.22% to 2.16%. Solar dried samples recorded the highest (2.22%) followed by Oven dried samples (2.19%) with Sun dried samples recording the least (2.16%) Ash, however these variations where not statistically different from each other ($p<0.05$).

There were significant differences ($p>0.05$) between the yam varieties in terms of Ash where mean values ranged between 2.32% to 2.02%. Dente recorded the highest mean of 2.32% which was significantly different from Pona (2.02%) but not significantly from Labreko (2.22%). Pona recorded the least mean of 2.02%.

The interaction effect of the yam varieties and drying method show some significant differences ($p<0.05$). Oven dried Labreko recorded the highest Moisture of 2.53% statistically different from that of Oven dried Pona, Sun dried Pona and Solar dried Labreko with value of 1.73%, 2.07%, and 2.00% respectively however it was not statistically different from Solar dried Pona, Oven dried Labreko, Sun dried Labreko, Oven dried Dente, Sun dried Dente, Solar dried Dente with values of 2.27%, 2.53%, 2.13%, 2.30%, 2.27% and 2.40% respectively.

Sun dried Labreko recorded the least Ash value of 1.73% which was significantly different from Solar dried Pona, Oven dried Labreko, Sun dried Labreko, Oven dried Dente, Sun dried Dente, Solar dried Dente with values of 2.27%, 2.53%, 2.13%, 2.30%, 2.27% and 2.40% respectively.

4.5.3 Protein

There were no significant differences ($p>0.05$) between the drying methods where mean values ranged from 5.01% to 4.76%. Oven dried samples recorded the highest (5.01%) followed by Sun dried samples (4.81%) with Solar dried samples recording the least (4.76%) Protein, however these variations where not statistically different from each other ($p<0.05$).

There were significant differences ($p>0.05$) between the yam varieties in terms of Protein where mean values ranged between 5.30% to 4.52%. Labreko recorded the highest mean of 5.30%

which was significantly different from Pona (4.76%) and Dente (4.52%). Dente recorded the least mean of 4.52%.

The interaction effect of the yam varieties and drying method show some significant differences ($p<0.05$). Oven dried Labreko recorded the highest Protein of 5.54% which is not statistically different from that of Oven dried Pona (4.96%), Sun dried Labreko (5.25%) and Solar dried Labreko (5.10%), however it was statistically different from Sun dried Pona (4.81%), Solar dried Pona (4.52%), Oven dried Dente(4.52%), Sun dried Dente (4.38%), Solar dried Dente (4.67%).

Sun dried Dente recorded the least Protein value of 4.38% which was significantly different from Oven dried Labreko (5.10%), Sun dried Labreko (4.52%), Solar dried Labreko (4.38%).

4.5.4 FAT

The mean values for the drying methods ranged from 0.78% to 0.51% with Solar dried samples recording the highest (0.78%) statistically different ($p<0.05$) from Oven (0.56%) which came second and Sun (0.51%) which came least.

There were significant differences ($p<0.05$) between the yam varieties in terms of Fat with mean values ranging between 0.83% to 0.50%. Labreko recorded the highest mean of 0.83% which was significantly different from Pona (0.51%) but not different from Dente (0.50%).

The interaction effect of the yam varieties and drying method showed some significant differences ($p<0.05$). Solar dried Labreko recorded the highest Fat of 1.33% which is statistically different from all the other samples except.

Oven dried Pona, Sun dried Pona, Solar dried Pona, Sun dried Labreko, Oven dried Dente and Solar dried Dente recorded the least Fat of 0.05% which was not significantly different from Oven dried Labreko (0.67%) and Sun dried Dente.

4.5.5 FIBER

There were no significant differences ($p>0.05$) between the drying methods where mean values ranged from 5.01% to 5.00%. Oven and Sun dried samples recorded the highest (5.01%) while Solar dried samples recorded least with 5.00%.

There were significant differences ($p<0.05$) between the yam varieties in terms of Fiber. Mean values ranged from 5.36% to 4.55% with Labreko recorded the highest mean of 5.36% which was significantly different from Dente (5.10%) and Pona (4.55%). Variations were significantly different from each other as Pona recorded the least mean of 4.55%.

The interaction effect of the yam varieties and drying method showed some significant differences ($p<0.05$). Oven dried Labreko recorded the highest Fiber of 6.02% which is statistically different from all the other samples.

Oven dried Pona recorded the least Fiber value of 4.00% which was significantly different from all the other samples.

4.5.6 Carbohydrate / NFE

The mean values for the drying methods ranged from 81.59% to 75.71% with Oven dried samples recording the highest (81.59%) followed by solar dried samples (77.90%) and Oven dried samples recording the least (75.71%) Carbohydrate, however these variations where statistically different from each other ($p<0.05$).

There were significant differences ($p<0.05$) between the yam varieties in terms of Carbohydrate where mean values ranged from 81.25% to 76.51%. Pona recorded the highest mean of 81.25% which was significantly different from Dente (77.44%) and Labreko (76.51%).

The interaction effect of the yam varieties and drying method showed significant differences ($p<0.05$). Oven dried Pona recorded the Highest Carbohydrate of 84.80% which is statistically different from all the other samples.

Sun dried Dente recorded the Least Carbohydrate of 74. 19% which was not significantly different from Sun dried Labreko (74.45%) but significantly different from the other samples.

4.6 PASTING PROPERTIES

4.6.1 Peak Viscosity

Peak Viscosity values for the drying methods ranged from 381.67% to 345.11% with Oven dried samples recording the highest of 381.67% which was significantly different ($p<0.05$) from Solar dried samples (345.11%). Sun dried samples (361.00%) was not significantly different from Oven dried samples (381.67%) but was significantly different ($p>0.05$) from Solar dried samples (345.11%).

There were significant differences ($p<0.05$) between the yam varieties in terms of Peak Viscosity where mean values ranged from 448.11 to 283.44%. Pona recorded the highest mean of 448.11% which was significantly different from Labreko (356.22%) and Dente (283.44%).

The interaction effect of the yam varieties and drying method showed significant differences ($p<0.05$). Sun dried Pona recorded the Highest Peak Viscosity of 458.67% which was statistically different from Oven dried Labreko, Sun dried Labreko, Solar dried Labreko, Oven dried Dente, Sun dried Dente and Solar dried Dente with values 374.00%, 364.67%, 330.00%, 313.33%, 259.67% and 277.33% respectively.

Sun dried Dente recorded the Least Peak Viscosity of 259.67% which was not significantly different from Solar dried Dente (277.33%) but significantly different from the other samples.

4.6.2 Pasting Stability

There were no significant differences (p>0.05) between the drying methods where mean values ranged from 49.11% to 47.33%. Sun dried samples recorded the highest (49.11%) followed by Oven dried samples (48.44%) with Solar dried samples recording the least (47.33%) Pasting Stability, these variations where however not statistically different from each other (p<0.05).

There were significant differences (p<0.05) between the yam varieties in terms of Pasting Stability where mean values ranged from 88.00% to 16.44%. Dente recorded the highest mean of 88.00% which was significantly different from Pona (40.44%) and Labreko (16.44%). Dente recorded the least mean of 4.52%. Dente (16.44%) recorded the Least and was not significantly different (p<0.05) from Pona (40.44%).

The interaction effect of the yam varieties and drying method showed some significant differences (p<0.05) with ranges from110.00% to 5.33%. Sun dried Dente recorded the highest Pasting Stability of 110.00% which was statistically different from all the other samples.

Oven dried Labreko recorded the least Pasting Stability value of 5.33%% which was not significantly different from Sun dried Labreko (10.67%), but was significantly different (p<0.05) from the other samples

4.6.3 Setback

The mean values for the drying methods ranged from 72.56% to 58.11% with Sun dried samples recording the highest (72.56%) statistically different ($p<0.05$) from Oven (49.00%) which came Least and not significantly different from Labreko (58.11%).

Yam varieties recorded significant differences ($p<0.05$) in terms of Setback with mean values ranging from 105.22% to 21.67%. Pona recorded the highest mean of 105.22% which was significantly different from Labreko (52.78%) and Dente (21.67%).

The interaction effect of the yam varieties and drying method showed some significant differences ($p<0.05$) ranging from 119.00% to 10.33%. Sun dried Pona recorded the highest Setback of 119.00% which was not statistically different ($p>0.05$) from Solar dried Pona (112.33%) but significantly different ($p<0.05$) from all the other samples.

Oven dried Dente recorded the Least Setback of 10.33% which was significantly different ($p<0.05$) from Oven dried Pona, Sun Dried Pona, Solar dried Pona, Oven dried Labreko and Sun dried Labreko with values of 84.33%, 119.00%, 112.33%, 52.33% and 63.00% respectively.

4.6.4 Breakdown

Breakdown for drying methods ranged from 39.44% to 14.89% with Oven dried samples recording the highest (39.44%) statistically different ($p<0.05$) from Sun dried samples (16.89%) which followed next and Solar dried samples (14.89%) recording Least.

Yam varieties recorded significant differences ($p<0.05$) in terms of Setback with mean values ranging from 56.00% to 0.56%. Dente recorded the Least mean of 0.56% which was significantly different ($p<0.50$) from Labreko (14.67%) and Pona (56.00%).

The interaction effect of the yam varieties and drying method showed some significant differences ($p<0.05$) ranging from 92.00% to 0.33%. Sun dried Dente recorded the Least Breakdown of 0.33% which was statistically different ($p<0.05$) from Oven dried Pona (92.00%), Sun dried Pona (37.00%), Solar dried Pona (39.00%) and Oven dried Labreko (25.67%) but not significantly different ($p>0.05$) from Sun dried Labreko(13.33%), Solar dried Labreko (5.00%), Oven dried Dente (0.67%) and Solar dried Dente (0.67%).

Oven dried Pona recorded the Highest Breakdown of 92.00% which was significantly different ($p<0.05$) from all the other samples.

4.7COLOUR PROPERTIES

4.7.1 Browning Index

Browning Index for drying methods ranged from 27.44% to 9.28% and showed significant differences ($p<0.05$). Sun dried samples recorded the highest (27.44%) Brown index which was statistically different ($p<0.05$) from Oven dried samples (9.28%) which recorded the Least.

Yam varieties recorded significant differences ($p<0.05$) in terms of Browning Index with mean values ranging from 22.32% to 17.90%. Least mean of 17.90% Browning Index was recorded for Pona which was significantly different ($p<0.50$) from Dente (22.32%) and Labreko (22.17%).

The interaction effect of the yam varieties and drying method showed significant differences ($p<0.05$) ranging from 31.44% to 6.57%. Sun dried Dente recorded the Highest Browning Index of 31.44% which was statistically different ($p<0.05$) from Oven dried Pona (8.43%), Sun dried Pona (20.23%), Oven dried Labreko (19.17%) and Oven dried Dente (10.24%).

Oven dried Pona recorded the Least Browning Index of 8.43% which was significantly different ($p<0.05$) from Sun dried Pona, Solar dried Pona, Sun dried Labreko, Solar dried Labreko, Sun dried Dente and Solar dried Dente with values of 20.23%, 25.05%,30.66%, 26.69%, 31.44% and 25.27% respectively.

TABLE 4.10: EFFECT OF COLOUR PROPERTIES ON THE DRYING METHODS

Drying Method	Lightness/Darkness %	Browning Index %
Oven	90.72 a	9.28 b
Sun	72.56 b	27.44 a
Solar	74.33 b	25.67 a
Lsd @ 5%	3.79	3.79
% Cv	4.79	18.26

Means value of three replicates

Sample means followed by the same superscript in a column are not significantly different (p>0.05)

TABLE 4.11: EFFECT OF COLOUR PROPERTIES ON THE VARIETIES

Variety	Lightness/Darkness %	Browning Index %
Pona	82.19 a	17.90 b
Labreko	77.83 b	22.17 a
Dente	77.68 b	22.32 a
Lsd @ 5%	3.79	3.79
% Cv	4.79	18.26

Means value of three replicates

Sample means followed by the same superscript in a column are not significantly different (p>0.05)

TABLE 4.12: EFFECT OF COLOUR PROPERTIES ON THE YAM FLOUR SAMPLES

Flour	**Lightness/Darkness %**	**Browning Index %**
Pona Oven	91.57 a	8.43 c
Pona Sun	79.77 b	20.23 b
Pona Solar	74.95 bc	25.05 ab
Labreko Oven	90.83 a	9.17 c
Labreko Sun	69.34 c	30.66 a
Labreko Solar	73.31 bc	26.69 ab
Dente Oven	89.76 a	10.24 c
Dente Sun	68.56 c	31.44 a
Dente Solar	74.73 bc	25.27 ab
Lsd @ 5%	6.57	6.57

Means value of three replicates

Sample means followed by the same superscript in a column are not significantly different ($p>0.05$).

5.0 DISCUSSION

5.1 SURVEY

5.1.1 Background Information on Retailers and Producers

From the results, it can be constructed that females were engaged in yam retailing than males (Figure 4.1) while males dominated females in the production area (Figure 4.2). The high female to male ratio in agriculture in most of the markets could be due to more females engaging in petty trading or migrating into urban areas in search of better livelihood than males while mores males are engaged in farming.

The study also revealed that retailers and producers within the economically active age group dominated. Respondents in the market centers recorded a dominate age group of 30 – 40 years while the producers also dominated with 30 – 40 years. It can be concluded that the youth in the producing areas and market centers were less interested in farming and retailing as a profession.

Majority of the retailers and producers interviewed had no formal education, this is mainly because they began their trade right from birth following their parents and helping them in their trade.

Extra economic activities engaged in by the farmers include trading, dressmaking and palm wine tapping. Farmers engaged in these activities to supplement the income generated in the farming activity. KMA (2007), draft report indicated that agriculture played a major economic role in employing many of the rural population in the Ashanti Region. In the market centers, retailers sorely engaged in yam trading as it is a very lucrative business venture for them.

5.1.2 Production Practices Carried Out

Yam is an all season crop with its major season around July to January and minor season February to June. There are lots of yam producing centers in the country with the northern region been the highest and these yam on the market centers come from these areas. Varieties on the other hand are a lot and vary among the producing areas. Over 32 different varieties were mentioned by the respondents.

Pona, Labreko and Dente are the most popular varieties among the lot and this is due to high demand, size, taste, quality etc. Pona is very big and a tuber can feed an entire family, labreko has a very sweet taste but it's smaller compared to the Pona. Dente on the other hand is the third choice preferred.

5.1.3 Knowledge on Flour Production

Yam flour is not a very common product of yam though a lot of products can be obtained from yam. Yam itself has a lot of uses which includes food, processing, feed for animals and others and can also be processed into other food products like flour, chips, pudding etc. 'Kokonte' is a very common delicacy prepared from yam flour and the chips are commonly dried by the use of the sun.

5.1.4 Post Harvest Handling

Yams are stored when brought to the markets because they are not immediately sold. Losses due occur during storage and this may be caused by rotten tubers, holes bore by pests and infections caused by various diseases and these do affect sales.

5.2 LABORATORY STUDIES

5.2.1 FUNCTIONAL PROPERTIES

5.2.1.1 Bulk Density

Bulk density is a measure of heaviness of a flour sample and is influenced by the structure of the starch polymers and loose structure of the starch polymers could result in low bulk density.

The bulk densities of the flours were above the range (0.49-0.63g/cm^3) reported for yam (Hsu *et al*., 2003) and this result shows that the flours will increase the bulkiness of food when used in food formulation.

5.2.1.2 Water Absorption

The water absorption capacity describes water association ability under limited water supply and is an important functional property required in food formulations especially those involving dough handling such as yam fufu (Udensi *et al*, 2008).

However, a lower water absorption capacity was observed in the sun-dried samples. Low water absorption capacity is attributed to a close association of starch polymers in the native granules (Jimoh, 2009).

It may also be due to the dissociation of protein subunits as the temperature of the oven-dried samples was higher than that of solar and sun-dried samples. The protein dissociation may have resulted in exposure of hydrophobic sites of the protein resulting in reduced absorption (Jimoh *et al.*, 2009).

For labreko, the observed variation in water absorption capacity for oven-dried flours may be due to change induced by the different drying methods. Probably the conformational characteristics and degree of interaction with water was modified by Oven drying resulting in the Oven dried flour having the highest water absorption capacity – 210% (Appiah *et al*., 2011).

Water absorption capacity of flour is a useful indicator of whether protein can be incorporated with the aqueous food formulations, especially, those involving dough handing. Interactions of protein with water, is important to properties such as hydration, swelling power solubility, and gelation. The high water absorption capacity of the flours suggests they could be useful in soup formulations (Appiah *et al.*, 2010).

5.2.1.3: Oil Absorption

The oil absorption capacity is important as oil acts as a flavour retainer and improves the mouth feel of foods (Abulude *et al.,* 2006). The lower oil absorption capacity of yam flour might be due to low hydrophobic proteins which show superior binding of lipids (Oladele, 2007).

The oil absorption capacity observed for the three cultivars were higher than that of cassava flour (1.5 g g^{-}1; Okezie and Bello, 1988) but lower than that of lesser yam (1.9 g g^{-}1; Ukpabi, 2010). Fat absorption is attributed to the combination of fats to the non-polar groups of proteins or the availability of the lipophilic groups (Kinsella, 1976). The high oil absorption capacity of the flours from the three cultivars may be due to the fact that flours had low oil content and high hydrophobic proteins which show superior binding of lipids (Kinsella, 1976). Since the flours had good oil absorption capacity it suggests that the presence of good lipophilic constituents. Consequently, since fats serve as carriers of flavour enhancers, the high Oil Absorption Capacity of the flours indicate they could hold more fat and therefore aid in enhancing the flavour of foods in which they are used (Kinsella, 1976).

According to *Appiah et al* (2010) lipid binding is dependent on the surface availability of hydrophobic amino acids. Oil absorption capacity is important as oil acts as flavor retainer and gives soft texture to food improving mouth-feel. Since the flours had good oil absorption capacity it suggests the presence of good lipophilic constituents and therefore may be suitable for production of sausage, soups and cakes

There was no significant difference in the oil absorption capacity of the oven-dried, solar-dried and sun-dried flour of the yam cultivars; hence the drying method did not have any effect on the different yam cultivars.

5.2.1.4: Swelling power

Swelling power of flour is the first stage in the initiation changes in hydration related properties. Drying methods did not have any effect on the swelling power of the samples investigated. The swelling power ranged between 3.57 and 6.33g. However, the result obtained is comparable to the 3.89 and 6.63% reported by Jimoh *et al.* (2009) and 3.89 g/g and 4.86 g/g for two *Dioscorea rotundata* cultivars (Omolokun and Abuja) and 4.05 g/g and 6.63 g/g for two *Dioscorea alata* cultivars (Tda 98/01166 and Tda 92-2) by Jimoh *et al.*, (2009).

The swelling power of flour samples is often related to their protein and starch contents. Higher protein content in flour may cause the starch granules to be embedded within a stiff protein matrix, which subsequently limits the access of the starch to water and restricts the swelling power. Flours lower in protein and higher in total starch content have a higher swelling ability. In addition to protein content, a higher concentration of phosphorous may increase hydration and swelling power by weakening the extent of bonding within the crystalline domain (Aprianita,

2009). A low swelling power was observed in Solar-dried flour, this may be due to stronger bonding force in its starch granules (Jimoh *et al.* 2009).

The low swelling power observed in the Oven-dried and Solar-dried samples for the cultivars may be due to the strong bonding force in the starch granules that prevented the samples from swelling easily (Jimoh *et al.,* 2009). The swelling power has being related to the associative binding within the starch granule within the flour, and apparently, the strength and character of the micellar network is related to the amylose content of the flour, low amylose content produces high swelling power (Pomeranz, 1991). The relatively high values observed in the Sun-dried flour may be due to the low amylose content.

5.2.1.5 Solubility

The results for solubility were lower than the reported solubility range of 7.57% and 10.46% for cassava by Baafi and Safo-Kantanka (2007). Decrease solubility could be attributed to the amylase content, since the solubilised amylose molecules leach from the swelled starch granules of flour (Dengate, 1984). According to the authors solubility of flour is an indicator of its quality. The high solubility values observed in the oven-dried samples of the flour suggests they could be very digestible and therefore could probably be suitable for infant food formulations.

Solar-dried flours of Labreko resulted in the highest solubility. Jimoh *et al*., (2009), attributed high solubility indices in starches to the easy solubility of the linear fraction (amylase) which is linked loosely with the rest of the macro molecular structure, and released or leached out during the swelling process.

According to Chin-Lin Hsu (2003), solubility index reflects the extent of starch degradation, this indicates that, Pona Sun-dried showed the least starch degradations while Labreko Solar-dried showed more profound effects on starch degradation.

5.2.1.6 Foam Capacity and Stability

The foaming capacity (FC) of a protein refers to the amount of interfacial area that can be created by the protein and foam stability (FS) refers to the ability of protein to stabilize against gravitational and mechanical stresses (Fennema, 1996). Foam formation and foam stability are a function of the type of protein, pH, processing methods, viscosity and surface tension. The Foam Capacity and Foam Stability of the Yam flour of the Cultivars and Drying methods attained no significant differences. The foam produced by Oven dried Labreko flours was relatively thick with high foam volume but low foam stability. The results indicated that the flour samples of the various cultivars are a good foaming agent.

Similar observation was reported by Yu *et al*. (2007) for roasted peanut. The results of foam stability of the Yam flour are presented in Table 1, 2 and 3. The flour samples showed high foam stability for Solar dried Pona with 51.87ml/g. Similar observation was reported for field pea flour (Kaur *et al*., 2006). The results obtained suggesting that the native proteins are soluble in the continuous phase (water) is very surface active in Yam flour. Therefore, Yam flours may be suitable in food system that requires a high percentage of porosity such as cake and ice cream.

5.2.1.7: Least Gelation Concentration

The least gelation concentration observed in the oven-dried yam flours for the cultivars were significantly higher ($p<0.05$) than the solar and sun-dried yam flours for the three yam cultivars. Gossette *et al*., (1984) stated that gelation is an aggregation of denatured molecules. The higher least gelation concentration observed in the oven-dried yam flour may be attributed to the temperature of the oven dryer (70 ^{O}C) which resulted in more denatured molecules. Gelation involves the swelling of starch granules on heating, the low gelation concentration of the solar and sun-dried yam flours could be attributed to higher level of total available carbohydrate than in the oven-dried Dente and Pona yam flours. The results show that the solar and sun-dried yam flours would be a good firming agent, and would be useful in food systems such as pudding and snacks which require thickening

The higher least gelation concentration observed may be as a result of more of the molecules being denatured. According Moorthy (2002), higher range has been attributed to a higher level of crystallinity, which imparts higher structural stability so that the water molecules need longer time to penetrate the crystalline areas. Variation in gelation properties might be due to the ratio of different constituents such as proteins, lipids and carbohydrates in the different species (Yemisi, 2007).

5.2.2 PROXIMATE ANALYSIS

5.2.2.1 Moisture Content

The percentage moisture content of the yam cultivars ranged between 4.00% - 13.33%. Oven – dried flours of the three cultivars recorded the lowest moisture content, this indicate that flours from the oven-dried will store longer when placed under the same storage conditions because of the low moisture content. The results tallies with the findings of Abulude (2006), on raw and processed rice.

According to Abulude (2006), the low moisture content of the samples would hinder the growth of micro-organisms and the storage life would be high. It has been reported by Ojokoh *et al* (2010), that, fungal growth in agricultural produce is directly correlated to the moisture content.

The relatively low moisture content of the Oven-dried samples may be due to the constant temperature (70 ^{O}C) in the oven during drying (Omonigho and Ikenebomeh, 2000). The solar-dried samples were significantly lower ($p<0.05$) than the sun-dried samples due to the fact that, solar dryers can increase the temperature in it chamber to about 10 ^{O}C -30 ^{O}C and also has the ability to store heat in it chamber even after sun set for drying to continue during the night (Aliyu and Jibril, 2009). The relatively high moisture content observed in the Sun dried may be due to the uncontrolled temperature which was lower than in the solar and oven dryers.

The relative low moisture content in the oven-dried flours of the two cultivars will logically make for the extended postharvest utilization of this perishable crop as low moisture activity in food materials discourages the growth of plant pathogenic micro-organisms (Ukpabi, 2010).

5.2.2.2 Ash

Ash (in analytical food chemistry) is one of the components in the proximate analysis of biological materials, consisting mainly of non-organic, carbonates and bicarbonates and metals. It is the name given to all compounds that are not considered organic or water. It includes metal salts, which are important for processes requiring ions such as Na^+ (Sodium), K^+ (Potassium), Ca^{2+} (Calcium). It also includes trace minerals, which are required for unique molecules, such as chlorophyll and hemoglobin. Ash may include any of the following: oxides e.g. Al_2O_3, CaO, Fe_2O_3, MgO, MnO, P_2O_5, K_2O, SiO_2, carbonates: Na_2CO_3 (soda ash), bicarbonates: $NaHCO_3$ (baking soda) (Osagie, 1992).

The ash content observed were higher than the reported values of 1.40% and 1.60% for white yam and white cocoyam respectively by Alinnor and Akalezi (2010) . The higher ash content observed in the flours can be attributed to the type of soil from which the yam tubers were harvested it was harvested (Osagie, 1992). The ash content is an indication of minerals present in the flour. The result indicates that the flour of yam cultivars could be a source of mineral elements having nutritional importance. The presence of other minerals such as iron is very essential for blood formation.

5.2.2.3 Protein

Proteins perform a surprising variety of essential functions in mammalian organisms. Dynamic functions include catalysis of chemical transformations, transport metabolic control and contraction. In their structural functions, proteins provide the matrix for bone and connective tissue, giving structure and form to the human organism (Devlin, 2002).

Protein content of samples ranges between 4.36% and 5.54% and can be compared to a study conducted by Trèche and Agbor-Egbe (1995) which reported a crude protein content of 4.7 to 15.6 g/ 100 g for *Dioscorea alata* (water yam). The crude protein values observed were lower than the mean values reported for sweet potato, 5.6 g/100g- 6.8 g/ 100g, but higher than the reported value for cassava roots, 1.7g/100g, (Gomez and Valdivieso, 1983). The crude protein content was also higher than the reported value of 3.16% observed in a local variety of *D. Rotundata* reported by Jimoh *et al*., (2009). The higher crude protein values observed in the Oven dried samples may be due to the fewer breaks down of proteins by enzymes (proteolysis), due to the relatively shorter period of drying as compared to the solar and sun drying.

Generally, higher protein content in yam is desirable for improved nutrition. However, protein content in yam is not as high as recorded for cowpea which ranges between 26.53 – 29.00 depending on the type of variety. The high protein content is indicative that its use could help reduce protein-deficiency (Appiah *et al*., 2011).

5.2.2.4: Crude Fat

Fat serve as a source of calories and are required to prevent or correct essential fatty acid deficiency (Lehne *et al*,. 1990).

The fat values observed for yam cultivars obtained under the three drying methods were high as compared to the values found in other root and tuber crops like potato (0.4g/100g-1, Bradbury and Holloway, 1988) and cassava (0.3g/100g-1, Richard and Coursey, 1981). The generally low crude fat content compared with conventional sources of oil is not surprising as yam is known to be a poor source of fat. However the relatively higher fat content observed in the Solar-dried Labreko sample suggest the flour could be good flavour retainers because of their higher fat content.

This also implies that the presence of fat in the yam flours suggests that, foods prepared from it will be more palatable and will contain the fat soluble vitamins, thus vitamin A, D, E and K.

5.2.2.5 Crude Fiber

Crude fiber is a measure of the quantity of indigestible cellulose, pentosans, lignin, and other components of this type may be present in foods. These components have little food value but provide the bulk necessary for proper peristaltic action in the intestinal tract.

The values observed for the yam flours obtained under the three drying methods were higher than the reported range of 0.75% to 1.03% for seven water yam varieties (Udensi *et al*., 2008) and 1.65% observed in a local cultivar of *D. rotundata* (Omolokun) as reported by Jimoh *et al*., (2009). The Oven-dried Labreko sample recorded the highest crude fibre content while Pona sample obtained under the same drying method had the lowest crude fibre value. The differences observed may be due to cultivar difference or genetics. Fibre refers to a group of substances that include plant polysaccharides and lignin that are resistant to the digestive enzymes. A high fibre diet affects most segment of the digestive system. The relatively high crude fibre content could be useful in providing bulk to foods to relieve constipation (Appiah *et al*., 2011).

5.2.2.6: Carbohydrate Content

Carbohydrates are essentially sugars. The primary sugar of the body is glucose. Glucose is the first line or preferential source of energy for the body. The body needs glucose in certain tissues and cells in order for them to function correctly. When the blood glucose (or ‘blood sugar') is low, the body will breakdown its glucose energy reserves to replenish the concentration of the blood glucose to the proper level. Glucose is stored in the body as a longer molecule called Glycogen. Glycogen is stored mostly in the liver and in much smaller amounts in muscles. When the blood sugar level drops, glycogen is broken down into its smaller units (glucose) and is released into the blood stream (Anonymous 2004).

The minimum amount of carbohydrate required to prevent the starvation activation systems (ketosis) of fasting is 100 to 150 grams per day. Carbohydrate is needed to satisfy the glucose requirement of the brain (120 Grams per day), red blood cell (30 grams per day) and wound healing (20 to 60 grams per day). These tissues primary fuel blood sugar or glucose and the muscle tissue is preserved by providing 180 to 200 grams of carbohydrate per day. This is the minimum carbohydrate requirement without the body resorting to breaking down other tissues to build new glucose (Anonymous 2004).

Carbohydrates are very essential for meeting the body’s energy requirements. This becomes even more vital if the person is conducting regular exercise. With regular exercise, the body’s energy requirements go up. If the carbohydrate intake is reduced, there is no doubt that some people might see some initial reduction in weight loss, but this is not sustained in the long term. Having a low carbohydrate diet will gradually lead to an increase in lethargy and will lead to a gradual increase in weight after the initial weight loss. Often the initial weight loss is actually just the decrease of fluids from the cells, or water weight. This loss of fluids is not always healthy (Harden, 2011). Although the actual amount of recommended carbohydrate is different from person to person, the total daily calories from carbohydrate intake should be in the range of 45% to 60% in a given day (Harden, 2011).

The carbohydrate content for flour samples observed under the three drying methods ranged between 74.19% and 84.80%. The values compared favourably with the 75.53%-87.64% obtained for water yam varieties (Udensi *et al*., 2008).

The higher amount of carbohydrate observed in the result suggest that the yam flours could be an important source of energy to consumers (Brown, 1991).

5.2.3 PASTING PROPERTIES

The behavior of flour/starch during cooking, gelatinization and pasting has been linked to its quality and suitability of use (Crosbie 1991; Moorthy, 2002). Pasting properties are therefore an important quality index in predicting the behavior of yam paste during and after cooking. The parameters recorded for each flour sample during the pasting cycle were pasting temperature, peak viscosity, viscosity at 95 ^{o}C (trough), viscosity at constant 95 ^{o}C (breakdown), viscosity at 50 ^{o}C (final viscosity) and viscosity at constant 50 ^{o}C (setback).

Flour diets prepared from cassava and yam on its own or as composites with cereal flours are cooked into semi-solid pastes referred to as ‘fufu’. Hence pasting properties of these flours are important indices in predicting the pasting behavior during and after cooking, (Richard et al 1991). The pasting properties of the yam flours composite flours are shown on Tables 7, 8 and 9.

5.2.3.1 Peak Viscosity

The final viscosity is the most commonly used parameter to determine a particular flour-based sample quality. It gives an idea of the ability of a material to gel after cooking. The final viscosity of the 100% Sun dried Dente flour recorded the highest value of 110.00, Brabender units (BU). The final viscosity is also the most commonly used parameters to define a particular sample quality (Martin *et al*, 1972).

Peak Viscosity is a measure of the ability of starch to form a paste; it indicates the highest value of viscosity during the heating cycle. Peak Viscosities attained during the heating portion of tests indicates the water binding capacity of starch mixtures. This often correlates with final product qualities. In this case the Sun dried Pona composite flour had the highest peak viscosity of 202.2

RVU. There were significant differences ($p < 0.05$) observed in the Peak Viscosities with respect to the Cultivars, Drying Methods and sample interactions and may be linked to the biological and morphological properties of that or those yam.

5.2.3.2 Pasting Temperature

The pasting temperature provides an indication of the minimum temperature required for cooking and also indicate energy costs .From table 7,8 and 9, the Pona variety has a higher gelatinization time and pasting temperature" an important advantage for ready-to-eat products.

This can be related to the variations observed for the Pona varieties from the Proximate and the functional properties.

The Pasting temperature which is the temperature at which viscosity first increases by at 25 RVU over 20 seconds (IITA, 2001) ranges from 94.27 ^{O}C to 95.10 ^{O}C. The pasting temperature is not significantly different ($p>0.05$) each other. Higher pasting temperature which is observed in Sun dried Pona (95.10 ^{O}C) implies higher gelatinization and lower swelling power of starch due to high degree of association between starch granules (Emiola and Delarosa., 1981). The amylograph pasting viscosities graphs are shown in appendices.

5.2.3.3 Peak Times

Peak time ranges from 30.33min to 43.87min of the yam flour samples are significantly different ($p<0.05$) where Sun dried Dente (43.87 min) had the highest Peak time and Oven dried Pona had the lowest Peak time (4.68 min).

5.2.3.4 Setback

Setback measures the re-association of starch and is associated with cohesiveness of amala (A Nigerians food prepared from yam flour. The setback values ranged from 112.33BU to 10.33BU.There is significant difference ($p<0.05$) in the setback of the yam flour samples while Oven dried Dente (10.33 BU) had the lowest set back value. The higher the setback, the lower the Retrogradation during cooling and the lower the rate of staling in yam flour products (Adeyemi and Idowu, 1990).

From table 7, 8 and 9, Oven dried Pona Sun dried Pona, and Solar dried Pona i.e. the Pona variety dried samples of all the yam flours were more cohesive than the other flours. Kin *et al.*, 1995, had earlier reported that a high setback value is associated with cohesive paste while a low value is an indication that the paste is not cohesive. Hence, the paste made from Pona variety is more cohesive than pastes made from other yam flours hence the Pona variety can be recommended for the preparation of 'fufu' or 'amala'.

Setback values have been reported to correlate with ability of starches to gel into semi solid pastes. These properties indicate that the sample possesses the highest ability of all the blends to remain undisrupted when subjected to long periods of constant high temperature and ability to withstand breakdown during cooking.

5.2.3.5 Breakdown

Breakdown measures the ability of starch to withstand breakdown during cooling, yam flour which ranged from 0.33BU to 92.00BU were significantly different ($p<0.05$). Oven dried Pona had the highest breakdown (92.00 BU). The higher the Break down in viscosity, the lower the ability of the sample to withstand heating and the shear stress during cooking (Adebowale *et al*.,2005) The breakdown of yam flour samples is the difference in the Peak viscosity and Trough viscosity (IITA. 2001).

Oduro *et al*., 2000, reported that starches with low paste stability or breakdown have very weak crosslinking within the granules. It therefore means that there is stronger cross-linking within the granules of Oven-dried Pona flour, probably due to the high temperature of drying. In addition, the drying method has a significant effect on the final viscosity of reconstituted yam flour paste.

5.2.4 COLOUR PROPERTIES

5.2.4.1 Browning Index

The results of colour is shown in table 10,11 and 12, It was observed that there is significant difference ($p < 0.05$) in the colour of the yam flour brownness index (8.43 to 31.44)% and lightness (68.56 to 91.57)% .

Oven dried Pona had the highest light colour of 91.57%. The extremely dark colour in some of the samples could be attributed to the presence of yam peels in the flour which imparts a darker colour. The percentage brownness in the yam flour samples were significantly different ($p<0.05$)

from each other and from the reference sample. Sun dried Dente had the highest brown colour of 31.44%, while Oven dried Pona had the lowest brownness index value of 8.43%.

High brown index may be ascribed to the activity of polyphenol oxidases as a result of the prolonged drying period and varietal differences.

Polyphenoloxidase is an oxidizing enzyme that is widespread in nature and is a protein of variable molecular weight (for example, 34,500 in mushrooms and 144,000 in tea leaves) that contains 0.2–0.3% copper. It catalyzes the oxidation of o-diphenols, as well as phenols, triphenols, and polyphenols, to produce the corresponding quinones; molecular oxygen acts as the hydrogen acceptor in this process.

Polyphenoloxidase apparently takes part in the respiration of plant cells (the reversible oxidation of polyphenols forms the intermediate stage for hydrogen transfer from a substrate to O_2 in plants). By oxidizing the amino acid tyrosine in animals and humans, it plays a role in the formation of pigments called melanins, which are present in the skin, hair, and iris. Polyphenoloxidase also oxidizes tannins in tea leaves and causes the color of rye bread.

6.0 CONCLUSIONS AND RECOMMENDATIONS

6.1 CONCLUSIONS

The study shows that there are a lot of yam varieties on the market but popular ones are Pona, Labreko and Dente. People prefer Pona to the others simply because of its big size, but Labreko has a better taste as compared to Pona. It also shows that Pona, Dente and labreko yam flours are rich source of carbohydrate and fiber. High fiber content from labreko cultivar under oven-dried would be a better source since it could be useful in providing bulk to foods to relieve constipation.

The low moisture content in the oven dried samples suggests that oven drying would help promote the shelf life of the flours. The high water absorption capacity of the flour observed in Pona cultivar obtained under oven-dried technology suggests that they would be useful functional ingredients in bakery products. High solubility value obtained from labreko oven- dried flour suggests that it is digestible and therefore could be suitable for infant food formulation.

The relatively high forming capacity and stability of the flour from the study suggests that the flour will find application in cake baking, whiteners, as reported by Paul and Southgate (1980). Foams are used to improve texture, consistency and appearance of foods. Labreko recorded the highest mean with the proximate and functional analysis, it’s not readily available as compared to Pona and Dente and also quite expensive to the others. Oven drying technology came out best followed by sun and solar.

6.2 RECOMMENDATIONS

1. further work should be carried out to determine the shelf life of the flours produced under the three different drying technologies and the flour.

2. the flour should be used for different food preparations and their acceptability evaluated.

3. government should pay more attention to yam production in the country as it can improve on its GDP growth.

4. government should provide storage facilities to help the problem of losses of our agricultural produce.

5. people should be encourage to patronize in yam flour.

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APPENDICES

APPENDIX A: FREQUENCY TABLES FOR THE FIELD SURVEY

Appendix A1: Sex of retailers

Market	Male	Female	Total
Krofrom (Moro)	30	70	100
Central (Bode)	10	90	100
Abinchi	20	80	100
Asafo	0	100	100
Bantama	0	100	100

Appendix A2: Age of retailers

Market	< 20 years	20 - 30 years	30 - 40 years	40 - 50 years	> 50 years	Total	Mean
Krofrom(Moro)	0	30	40	20	10	100	31.7
Central (Bode)	10	40	20	20	10	100	28.9
Abinchi	15	35	12	18	20	100	29.2
Asafo	0	40	45	5	10	100	32.6
Bantama	15	45	25	10	5	100	30.4

Appendix A3: Level of education of retailers

Market	Informal	JHS/MS	SHS/TECH/VOC	TERTIARY	Total
Krofrom (Moro)	90	10	0	0	100
Central (Bode)	60	40	0	0	100
Abinchi	75	20	5	0	100
Asafo	60	25	15	0	100
Bantama	80	20	0	0	100

Appendix A4: Cultivars preferred by retailers

Market	Pona	Labreko	Dente	Asobayire	Dokoba	Muchumudu	Total
Krofrom(Moro)	35	10	20	20	10	5	100
Central (Bode)	45	5	8	15	17	10	100
Abinchi	25	15	25	10	15	10	100
Asafo	50	5	15	20	5	5	100
Bantama	55	0	25	15	5	0	100

Appendix A5: Cultivars used for fufu by retailers

Cultivars	Frequency	Percentage
Pona	45	90
Labreko	1	2
Lelli	1	2
Dente	1	2
Numo	1	2
Serwaa	1	2
	50	100

APPENDIX B: ANALYSIS OF VARIANCE (ANOVA) TABLES

A. Functional Properties

1. ANOVA Table for Foam capacity

Source	DF	SS	MS	F	P
Replication	2	142.52	71.259		
Varieties	2	401.41	200.704	2.03	0.1641
Drying method	2	199.41	99.704	1.01	0.3872
Varieties*Drying method	4	492.37	123.093	1.24	0.3322
Error	16	1583.48	98.968		
Total	26	2819.19			

Grand Mean 52.741 CV 18.86

2. ANOVA Table for Foam stability

Source	DF	SS	MS	F	P
Replication	2	382.08	191.040		
Varieties	2	53.27	26.634	0.15	0.8651
Drying method	2	122.21	61.105	0.34	0.7199
Varieties*Drying method	4	2256.27	564.068	3.10	0.0458
Error	16	2914.71	182.169		
Total	26	5728.54			

Grand Mean 38.230 CV 35.31

3. ANOVA Table for Oil absorption

Source	DF	SS	MS	F	P
Replication	2	0.04222	0.02111		
Varieties	2	0.20667	0.10333	6.95	0.0067
Drying method	2	0.00222	0.00111	0.07	0.9283
Varieties*drying method	4	0.17111	0.04278	2.88	0.0569
Error	16	0.23778	0.01486		
Total	26	0.66000			

Grand Mean 9.0000 CV 1.35

4. ANOVA Table for Solubility

Source	DF	SS	MS	F	P
Replication	2	0.6756	0.33778		
Varieties	2	5.1200	2.56000	2.00	0.1682
Drying method	2	7.2622	3.63111	2.83	0.0885
Varieties*drying method	4	10.2978	2.57444	2.01	0.1418
Error	16	20.5111	1.28194		
Total	26	43.8667			

Grand Mean 6.2556 CV 18.10

5. ANOVA Table for swelling power

Source	DF	SS	MS	F	P
Replication	2	2.3696	1.18481		
Varieties	2	8.0385	4.01926	3.49	0.0552
Drying method	2	0.6452	0.32259	0.28	0.7592
Varieties*drying method	4	9.1393	2.28481	1.98	0.1454
Error	16	18.4170	1.15106		
Total	26	38.6096			

Grand Mean 4.8037 CV 22.33

6. ANOVA Table for Water absorption

Source	DF	SS	MS	F	P
Replication	2	0.19185	0.09593		
Varieties	2	1.35185	0.67593	7.33	0.0055
Drying method	2	0.09407	0.04704	0.51	0.6098
Varieties*drying method	4	0.53259	0.13315	1.44	0.2650
Error	16	1.47481	0.09218		
Total	26	3.64519			

Grand Mean 8.2593 CV 3.68

7. ANOVA Table for Bulk density

Source	DF	SS	MS	F	P
Replication	2	0.00031	0.00015		
Varieties	2	0.00035	0.00017	1.81	0.1962
Drying method	2	0.00269	0.00134	14.01	0.0003
Varieties*Drying method	4	0.00170	0.00042	4.42	0.0135
Error	16	0.00154	0.00010		
Total	26	0.00657			

Grand Mean 0.8304 CV 1.18

B. Proximate Analysis

8. ANOVA Table for Ash

Source	DF	SS	MS	F	P
Drying	2	0.02000	0.01000	0.15	0.8596
Varieties	2	0.42000	0.21000	3.20	0.0645
Drying*Varieties	4	0.90667	0.22667	3.46	0.0290
Error	18	1.18000	0.06556		
Total	26	2.52667			

Grand Mean 2.1889 CV 11.70

9. ANOVA Table for Fat (Ether Extract)

Source	DF	SS	MS	F	P
Drying	2	0.36623	0.18311	9.69	0.0014
Varieties	2	0.64290	0.32145	17.01	0.0001
Drying*Varieties	4	0.80268	0.20067	10.62	0.0001
Error	18	0.34007	0.01889		
Total	26	2.15187			

Grand Mean 0.6152 CV 22.34

10. ANOVA Table for Crude Fiber

Source	DF	SS	MS	F	P
Drying	2	0.00039	0.00019	0.22	0.8014
Varieties	2	3.08250	1.54125	1793.69	0.0000
Drying*Varieties	4	3.53253	0.88313	1027.78	0.0000
Error	18	0.01547	0.00086		
Total	26	6.63087			

Grand Mean 5.0052 CV 0.59

11. ANOVA Table for Moisture

Source	DF	SS	MS	F	P
Drying	2	176.889	88.4444	99.50	0.0000
Varieties	2	54.222	27.1111	30.50	0.0000
Drying*Varieties	4	3.556	0.8889	1.00	0.4332
Error	18	16.000	0.8889		
Total	26	250.667			

Grand Mean 8.8889 CV 10.61

12. ANOVA Table for Nitrogen-Free Extract (Carbohydrate)

Source	DF	SS	MS	F	P
Drying	2	158.705	79.3524	93.93	0.0000
Varieties	2	113.640	56.8198	67.26	0.0000
Drying*Varieties	4	4.286	1.0715	1.27	0.3188
Error	18	15.206	0.8448		
Total	26	291.836			

Grand Mean 78.401 CV 1.17

13. ANOVA Table for Crude Protein

Source	DF	SS	MS	F	P
Drying	2	0.29921	0.14960	1.01	0.3852
Varieties	2	2.84450	1.42225	9.57	0.0015
Drying*Varieties	4	0.41957	0.10489	0.71	0.5984
Error	18	2.67547	0.14864		
Total	26	6.23874			

Grand Mean 4.8615 CV 7.93

C. Pasting Characteristics

14. ANOVA Table for Gelatinization Temperature

Source	DF	SS	MS	F	P
Replication	2	0.007	0.0033		
Varieties	2	82.882	41.4411	1876.58	0.0000
Drying	2	23.162	11.5811	524.43	0.0000
Drying*Varieties	4	8.682	2.1706	98.29	0.0000
Error	16	0.353	0.0221		
Total	26	115.087			

Grand Mean 78.689 CV 0.19

15. ANOVA Table for Gelatinization Time

Source	DF	SS	MS	F	P
Replication	2	39.860	19.9302		
Varieties	2	44.298	22.1488	1.17	0.3365
Drying	2	8.491	4.2453	0.22	0.8021
Drying*Varieties	4	4.952	1.2379	0.07	0.9914
Error	16	303.706	18.9817		
Total	26	401.307			

Grand Mean 20.947 CV 20.80

16. ANOVA Table for Pasting Stability

Source	DF	SS	MS	F	P
Replication	2	130.3	65.1		
Varieties	2	23873.2	11936.6	453.61	0.0000
Drying	2	14.5	7.3	0.28	0.7625
Drying*Varieties	4	6320.6	1580.1	60.05	0.0000
Error	16	421.0	26.3		
Total	26	30759.6			

Grand Mean 48.296 CV 10.62

17. ANOVA Table for Peak Viscosity

Source	DF	SS	MS	F	P
Replication	2	212	106.0		
Varieties	2	122566	61282.9	119.34	0.0000
Drying	2	6048	3023.8	5.89	0.0121
Drying*Varieties	4	3487	871.8	1.70	0.1997
Error	16	8216	513.5		
Total	26	140529			

Grand Mean 362.59 CV 6.25

18. ANOVA Table for Peak Temperature

Source	DF	SS	MS	F	P
Replication	2	0.16074	0.08037		
Varieties	2	0.55630	0.27815	0.64	0.5390
Drying	2	0.14296	0.07148	0.17	0.8492
Drying*Varieties	4	1.04593	0.26148	0.60	0.6653
Error	16	6.92593	0.43287		
Total	26	8.83185			

Grand Mean 94.674 CV 0.69

19. ANOVA Table for Peak Time

Source	DF	SS	MS	F	P
Replication	2	2.699	1.349		
Varieties	2	675.665	337.832	479.84	0.0000
Drying	2	14.070	7.035	9.99	0.0015
Drying*Varieties	4	18.423	4.606	6.54	0.0026
Error	16	11.265	0.704		
Total	26	722.121			

Grand Mean 36.070 CV 2.33

20. ANOVA Table for Setback

Source	DF	SS	MS	F	P
Replication	2	672.2	336.1		
Varieties	2	32099.6	16049.8	40.47	0.0000
Drying	2	2539.6	1269.8	3.20	0.0677
Drying* Varieties	4	1086.2	271.6	0.68	0.6128
Error	16	6345.1	396.6		
Total	26	42742.7			

Grand Mean 59.889 CV 33.25

21. ANOVA Table for Breakdown

Source	DF	SS	MS	F	P
Replication	2	39.4	19.70		
Varieties	2	14945.0	7472.48	120.29	0.0000
Drying	2	3347.2	1673.59	26.94	0.0000
Drying*Varieties	4	3139.7	784.93	12.64	0.0001
Error	16	993.9	62.12		
Total	26	22465.2			

Grand Mean 23.741 CV 33.20

‘

D. Colour Properties

22. ANOVA Table for Lightness / Darkness

Source	DF	SS	MS	F	P
Replication	2	35.16	17.582		
Varieties	2	113.13	56.567	3.92	0.0410
Drying	2	1804.42	902.211	62.59	0.0000
Drying*Varieties	4	131.58	32.895	2.28	0.1055
Error	16	230.62	14.413		
Total	26	2314.92			

Grand Mean 79.203 CV 4.79

23. ANOVA Table for Browning Index

Source	DF	SS	MS	F	P
Replication	2	35.16	17.582		
Varieties	2	113.13	56.567	3.92	0.0410
Drying	2	1804.42	902.211	62.59	0.0000
Drying*Varieties	4	131.58	32.895	2.28	0.1055
Error	16	230.62	14.413		
Total	26	2314.92			

Grand Mean 20.797 CV 18.26

E2. Colour Properties

Sample/ Variety	Drying Method	Lightness/Darkness	Browning Index
Pona	Oven	91.516	8.484
	Sun	3.034	26.966
	Solar	75.062	24.938
Dente	Oven	89.728	10.272
	Sun	68.5	31.5
	Solar	74.704	25.296
Labreko	Oven	90.744	9.256
	Sun	69.176	30.824
	Solar	7 3.29	26.710

E3. Proximate Analysis

SAMPLE	MOISTURE (%)	ASH (%)	PROTEIN (%)	FAT (%)	FIBRE (%)	NFE (%)
PONA (Oven) R_1	4.00	1.80	4.81	0.50	4.00	84.89
R_2	4.00	1.60	5.25	0.50	4.01	84.64
R_3	4.00	1.80	4.81	0.51	4.00	84.88
PONA (Sun) R_1	10.00	2.20	4.81	0.50	4.70	77.59
R_2	10.00	2.40	4.81	0.50	4.74	77.55
R_3	8.00	1.60	4.81	0.50	4.73	80.36
PONA (Solar) R_1	8.00	2.20	4.38	0.50	4.89	80.03
R_2	8.00	2.20	4.81	0.50	4.90	79.59

R_3	6.00	2.40	4.38	0.50	4.99	81.73
DENTE (oven) R_1	6.00	2.20	4.38	0.50	5.00	81.05
R_2	6.00	2.20	5.25	0.50	5.00	81.05
R_3	8.00	2.50	3.94	0.50	5.00	80.06
DENTE (Sun) R_1	14	2.20	4.38	0.50	5.31	73.61
R_2	14	2.20	3.94	0.60	5.30	73.96
R_3	12	2.40	4.81	0.50	5.30	74.99
DENTE (Solar)R_1	10	2.40	4.81	0.50	5.01	77.28
R_2	10	2.40	4.81	0.50	5.00	77.29
R_3	10	2.40	4.38	0.50	5.01	77.71
Labreko (Oven) R_1	6.00	2.20	6.13	1.00	6.05	78.62
R_2	6.00	3.20	4.81	0.50	6.00	79.49
R_3	6.00	2.20	5.69	0.50	6.00	79.61
Labreko (Sun) R_1	14.00	2.20	5.25	0.50	5.00	73.05
R_2	12.00	2.00	5.25	0.50	5.00	75.25
R_3	12.00	2.20	5.25	0.50	5.00	75.05
Labreko (Solar) R_1	10.00	2.00	5.25	1.00	5.10	76.65
R_2	12.00	2.00	4.81	1.50	5.00	74.69
R_3	10.00	2.00	5.25	1.50	5.10	76.15

E4. Functional Properties

SAMPLE	Water Absorption (ml/g)	Oil Absorption (ml/g)	Foaming Capacity (g/ml)	Foaming Stability (g/ml)	Swelling Power (g/ml)	Bulk Density (g/ml)
PONA (Oven) R_1	8.6	8.9	50	40.0	5.9	0.83
R_2	8.6	9.2	55	54.5	1.2	0.85
R_3	8.6	9.1	55	27.3	3.6	0.86
PONA (Sun) R_1	8	9.4	50	20.0	5.5	0.82
R_2	8.3	9.1	70	14.3	5.1	0.82
R_3	8	9	50	50.0	4.2	0.81
PONA (Solar) R_1	8.6	9	45	55.6	4.7	0.82
R_2	8.4	9	50	50.0	4.8	0.82
R_3	8.4	9	50	50.0	5.7	0.81
DENTE (oven) R_1	6.8	8.9	70	28.6	4.6	0.83
R_2	8.4	9.1	30	33.3	5.2	0.85
R_3	8.2	9	65	38.5	5.0	0.83
DENTE (Sun) R_1	8.2	9.1	45	33.3	3.7	0.83
R_2	8	9.2	35	57.1	3.8	0.83
R_3	8	9.1	32	31.3	3.9	0.82
DENTE (Solar)R_1	7.9	9	55	27.3	5.1	0.83
R_2	8	9	40	50.0	2.1	0.85
R_3	8	9	60	33.3	5.5	0.85
Labreko (Oven) R_1	8.6	8.9	66	48.5	5.8	0.83

R_2	8.6	8.9	62	38.7	5.5	0.85
R_3	8.6	9	55	14.5	5.5	0.86
Labreko (Sun) R_1	8.4	8.6	58	69.0	6.4	0.81
R_2	8.4	9	48	62.5	6.6	0.81
R_3	8.4	8.6	62	32.3	6.0	0.82
Labreko (Solar) R_1	8.2	9	55	18.2	4.6	0.83
R_2	8.4	9	56	26.8	5.5	0.83
R_3	8.4	8.9	55	27.3	4.2	0.83

F. Pasting Curves

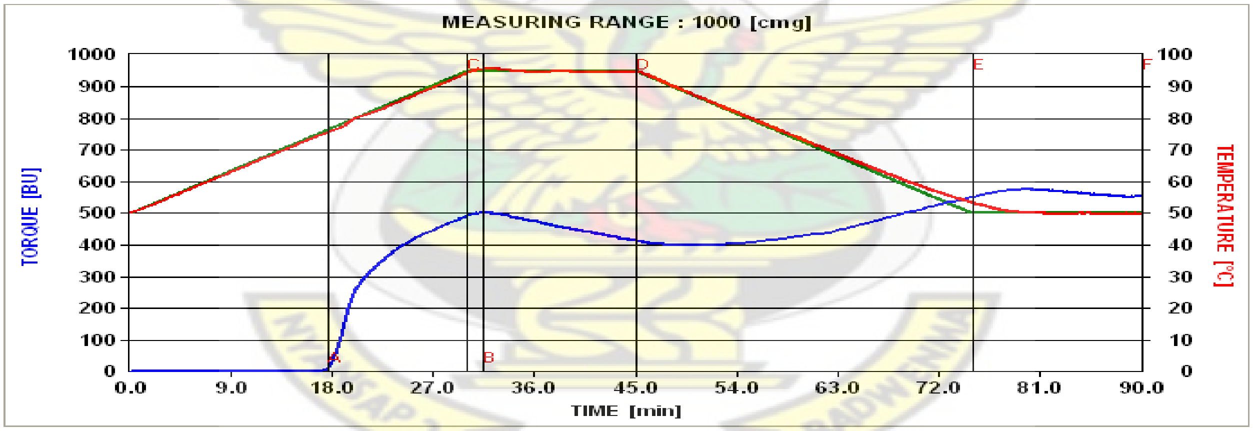

Figure 1. Pasting curves showing the different pasting properties of Oven dried Pona.

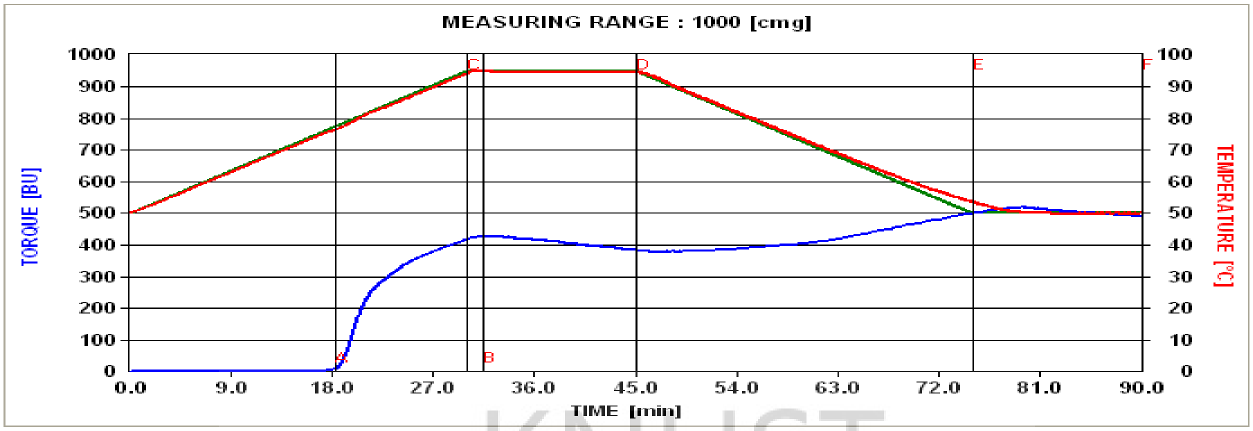

Figure 2. Pasting curves showing the different pasting properties of Solar dried Pona.

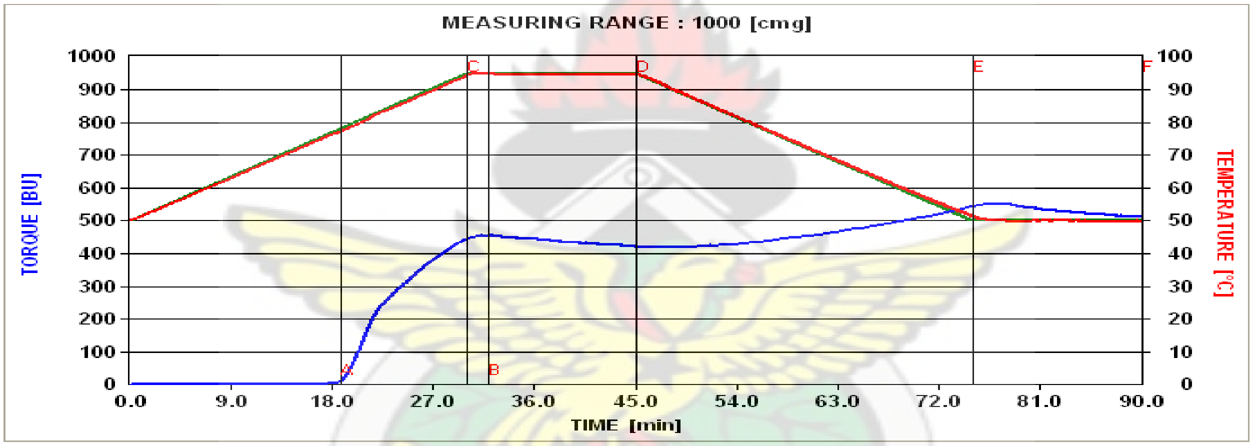

Figure 3. Pasting curves showing the different pasting properties of Sun dried Pona.

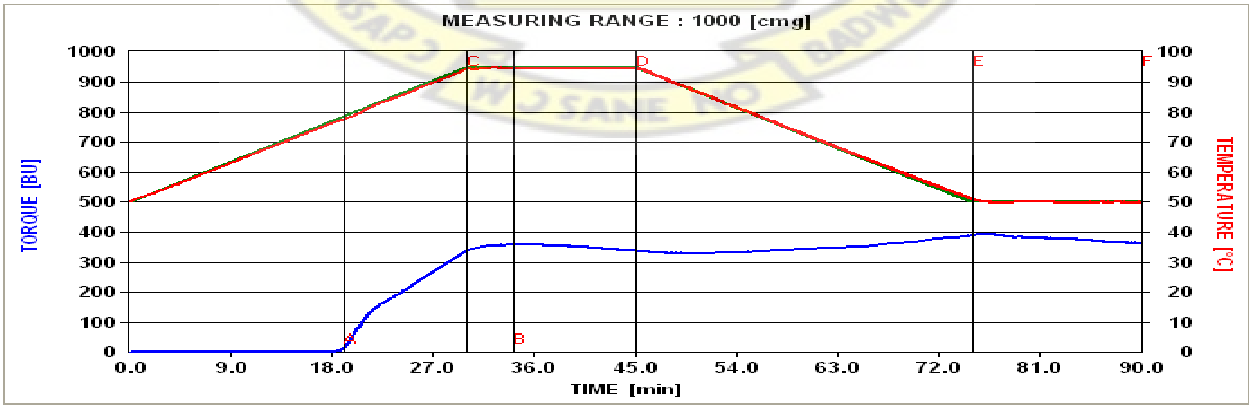

Figure 4. Pasting curves showing the different pasting properties of Oven dried Labreko.

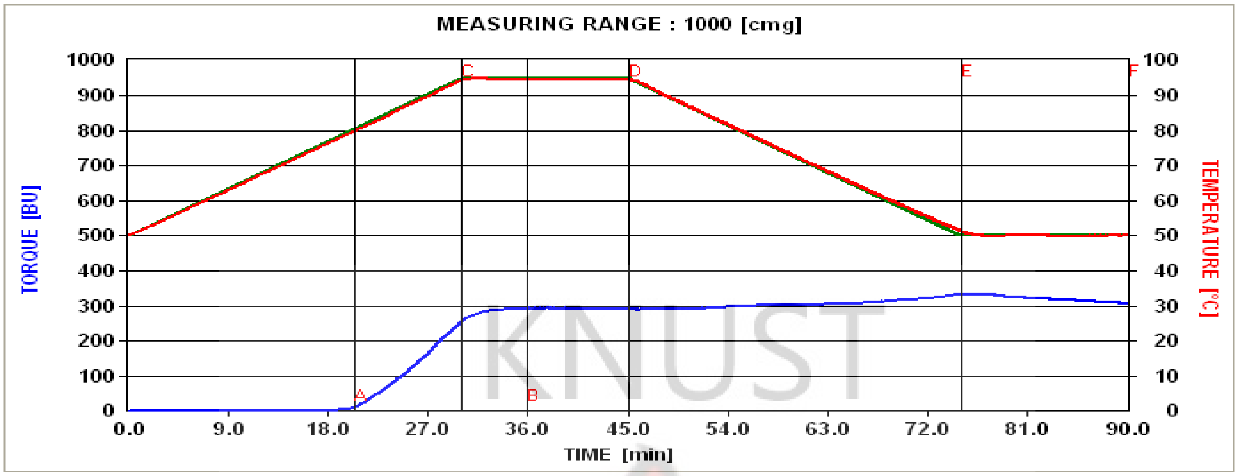

Figure 5. Pasting curves showing the different pasting properties of Solar dried Labreko.

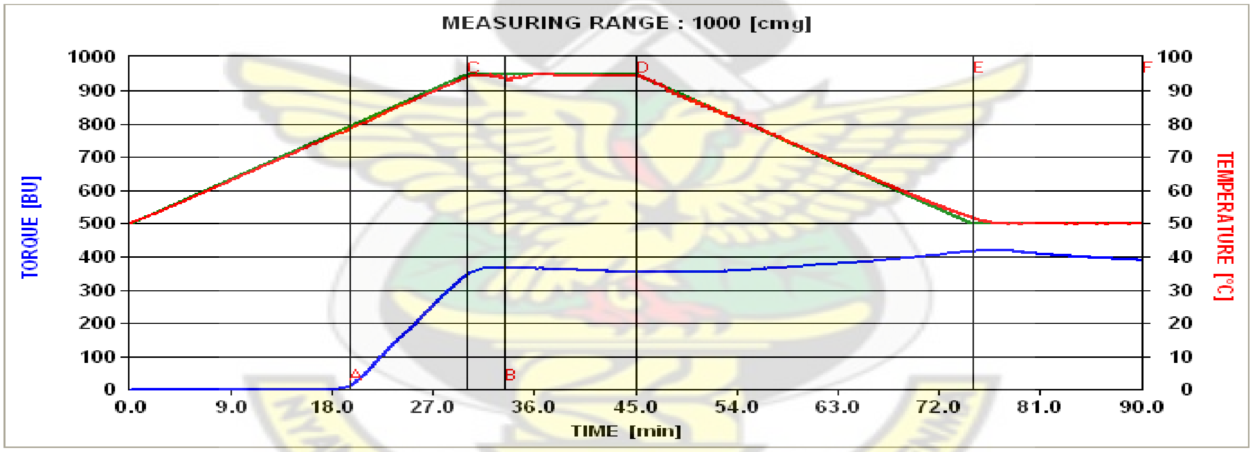

Figure 6. Pasting curves showing the different pasting properties of Sun dried Labreko.

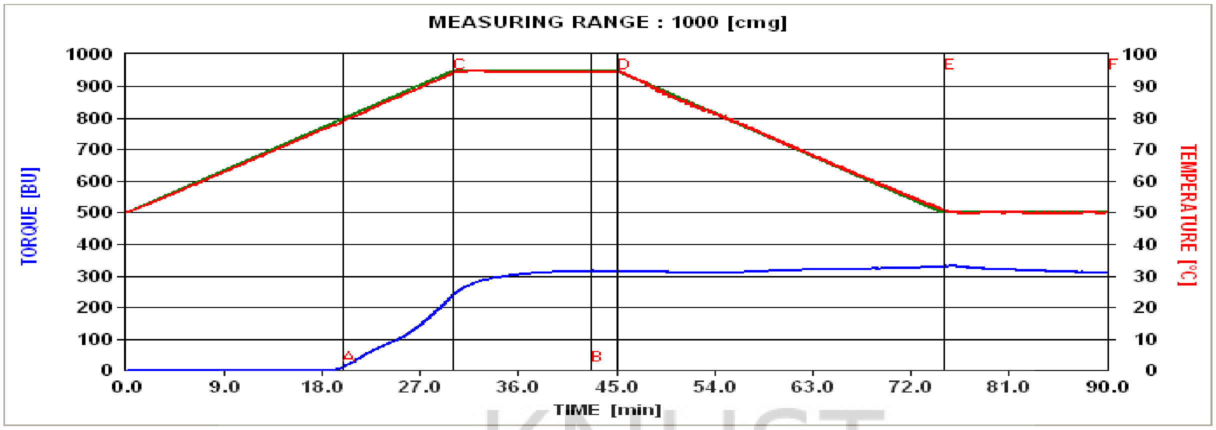

Figure 7. Pasting curves showing the different pasting properties of Oven dried Dente.

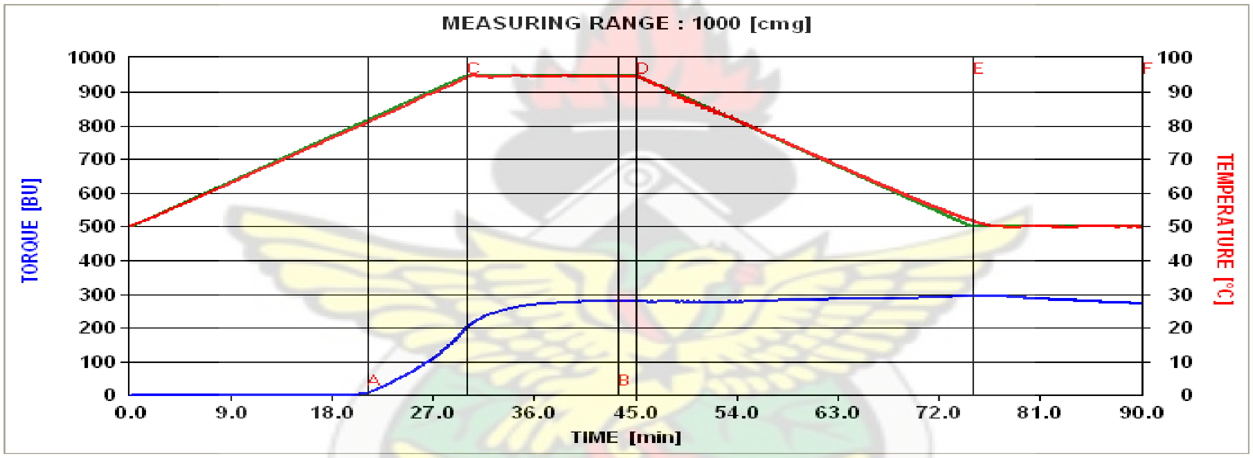

Figure 8. Pasting curves showing the different pasting properties of Solar dried Dente.

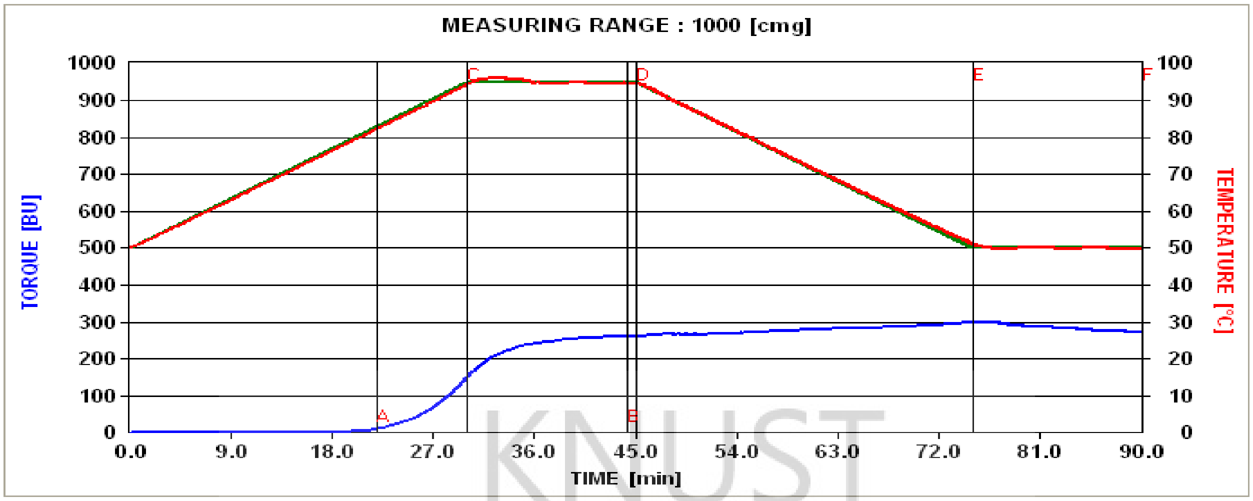

Figure 9. Pasting curves showing the different pasting properties of Sun dried Dente

APPENDIX C: SAMPLE QUESTIONNAIRE ADMINISTERED TO YAM RETAILERS

Kwame Nkrumah University of Science of Technology, Kumasi.
Department of Horticulture

This questionnaire was designed to evaluate the retail practices undertaken in some market centers in the Kumasi metropolis.

All information provided will be treated as confidential as possible. Please be as objective and brief as possible.

BIODATA

1. Sex of respondent — a. Male [ ] b. Female [ ]

2. Age of respondent — a. <20years [ ] b. 20-30years [ ] c. 30-40 [ ]
   d. 40-50 e. [ ] >50 [ ]

3. Education background — a. Informal [ ] b. JHS/MS [ ] c. SHS/TECH/VOC
   [ ] d. Tertiary [ ]

4. Market: — a. Krofrom (Moro) [ ] b. Central(Bode) [ ] c. Abinchi
   [ ] d. Asafo [ ] e. Bantama [ ]

PRODUCTION PRACTICES

5. Source of yam for sale — a. Market [ ] b. Farm [ ] c. Owned [ ]

6. Seasonality — a. Minor (February-June) [ ] b. Major (July–January)
   [ ] c. All year round [ ]

7. Cultivar sold — a. Pona [ ] b. Labreko [ ] c. Dente [ ]
   d. Asobayie [ ] e. Dokoba [ ] f. Muchumudu [ ]
   g. others: ………………………………..

8. Why that cultivar? — a. High quality [ ] b. High demand [ ] c. High price

d. Low price [ ] e. others: …………………………

9. Price per tuber a. <GHC1.00 [ ] b. GHC 1.00 – 1.50 [ ]
c. GHC 1.50 – 2.00 [ ] d. > GHC 2.00[

10. Size of tuber per price: a. Big [ ] b. Medium [ ] c. Small [ ]

11. Rate of sale: a. Fast moving [ ] b. Slow moving [ ]
c. Others ……………………………………….

KNOWLEGDE ON FLOUR PRODUCTION

12. Uses of yam a. Food [ ] b. Processing [ ] c. Feed for animals [ ]
d. Others ………………………………………….

13. Products of yam a. Fresh yam [ ] b. Flour [ ] c. Chips [ ]
d. Seeds [ ] e. Others ………………………………..

14. Varieties used for "fufu" a. Pona [ ] b. Labreko [ ] c .Lelli [ ] d. Dente [ ]
e. Numo [ ] f. Serwaa [ ]
g. others: ………………………..

15. Drying method used for processing into flour:
a. Sun [ ] b. Solar [ ] c. Air [ ]

16. Rate of sale of flour compared to other flour:
a. Fast moving [ ] b. Slow moving [ ] c. High demand [ ] d. Others …………..

POST HARVEST HANDLING

17. Are the yam purchased as they are brought to the market

a. Yes [ ] b. No [ ]

18. If No, do you store them a. Yes [ ] b. No [ ]

19. How do you store? a. Pack in a room [ ] b. Bury them [ ]

c. Pack under shade [ ]

20. Percentage losses during storage

a. < 10% [ ] b. 10% - 20% [ ] c. 20% – 40 % [ ] d. >50% [ ]

21. What are the nature of loss:

a. Rotten tubers [ ] b. Holes bored by Pests [ ] c. Infections caused diseases [ ]

22. Are there losses during selling: a. Yes [ ] b. No [ ]

23. Do the losses affect sales: a. Yes [ ] b. No [ ]

This questionnaire was designed to evaluate the production practices undertaken in some major yam producing areas in the Techiman - Tanoso metropolis.

All information provided will be treated as confidential as possible. Please be as objective and brief as possible.

BIODATA

1. Sex a. Male [ ] b. Female [ ]

2. Age a. <20years [ ] b. 20-30years [ ] c. 30-40 [ ]
   d. 40-50 e. [ ] >50 [ ]

3. Level of Education: a. Informal [ ] b. JHS/MS [ ] c. SHS/TECH/VOC
   [ ] d. Tertiary [ ]

PRODUCTION PRACTICES

4. Type of farming system a. Mono-cropping [ ] b. Mixed cropping with food
   crops [ ] c. Intercropping with cash crops [ ]
   d. others……………………………………………

5. Size of farm a. <5acres [ ] b. 5–10 acres [ ] c. 10–15acres [ ]
   d. 15-20acres [ ] e. >20[ ]

6. Source of planting material a. Research station [ ] b. farmer’s own [ ]
   c. farmers friend [ ] d. Others……………………

7. Cultivar grown? a. Pona [ ] b. Labreko [ ] c. Dente [ ]
   d. Asobayie [ ] e. Dokoba [ ] f. Muchumudu [ ]
   g. others: ……………………………………..

8. Why that cultivar? a. High quality [ ] b. High demand [ ]
   c. High price [ ] d. Low price [ ]

HARVESTING

9. When do harvest a. Morning [ ] b. Afternoon [ ] c. Evening [ ]

10. Why harvesting at this stage? …………………………………………………………

11. How many times do harvest in a month?

a. Once [ ] b. Twice [ ] c. Thrice [ ] d. others ……………………..

12. How many tubers do you harvest at a time?

a.10-20 [ ] b. 20-30 [ ] c. 30-40 [ ] d. others …………………

13. Period of harvesting a. Minor (February–June) [ ] b. Major (July–January) [ ] c. All year round [ ]

14. How do assemble after harvest

a. Pack in the sun [ ] b. Pack under shade [ ] c. others ………….....

MARKETING

15. Are the harvested yam sent immediately to the market:

a. Yes [ ] b. No [ ]

16. Do you sell at the farm gate?

a. Yes [ ] b. No [ ]

POST HARVEST HANDLING

17. Do you store after harvest before wholesale purchase?

a. Yes [ ] b. No [ ]

18. If yes, how do you store?

a. Pack in a room [ ] b. Bury in a pit [ ] c. Pack in a shade [ ]

d. others ……………………………………

19. Percentage losses during storage

a. < 10% [ ] b. 10% - 20% [ ] c. 20% – 40 % [ ] d. >50% [ ]

20. What are the nature of loss

a. Rotten tubers [ ] b. Holes bored by Pests [ ] c. Infections caused diseases [ ]

21. Do the losses affect sales: a. Yes [ ] b. No[ ]

KNOWLEDGE OF FLOUR PRODUCTION

22. Uses of yam	a. Food [ ] b. Processing [ ] c. Feed for animals [ ] d. others: …………………………
23. Products of yam	a. Fresh yam [ ] b. Flour [ ] c. Chips [ ] d. Seeds [ ] e. others: ……………………….
24. Varieties used for "fufu"	a. Pona [ ] b. Labreko [ ] c. Lelli [ ] d. Dente [ ] e. Numo [ ] f. Serwaa [ ] g. others: ……………………………………..

THANK YOU!